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Ware River intensive watershed study- Part 1. Nonpoint source contributions

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WARE RIVER INTENSIVE WATERSHED STUDY

1. Nonpoint Source Contributions

by

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ABSTRACT

Runoff quantity and quality were monitored for row crop, residential and forested lands in the Ware basin for the period of October 1979 to July 1981. Loading rates have been calculated for both baseflow and stormflow contributions at each study site.

Concentrations increased during stormflow periods for all water quality constituents except dissolved silica. On the average this increase was an order of magnitude greater than the baseflow concentrations for particulates, and by a factor of two for dissolved constituents. Concentrations of total phosphorous, nitrogen and dissolved ammonia were substantially higher in the runoff at the two agricultural sites than at the residential and forested catchments. The residential catchment had high concentrations of dissolved nutrients and BOD5 in both baseflow and storm runoff. Areal loading rates were controlled by runoff quantity rather than concentration. The residential site, which produced the greatest amount of storm runoff, also had the highest loading rates for all constituents except phosphorous and suspended solids, which had higher loadings from the cultivated land. The well drained upland farm produced the least runoff of the four catchments monitored and, consequently, had the lowest mass yield of most pollutants.

Baseflow accounted for a significant portion of the total flow at the forested and residential catchments, especially during winter months when the water table was high. In fact, nearly half of the total flow measured came from groundwater during the study period. However, storm runoff produced 83 and 70% of the total phosphorous and nitrogen loads, and 62 and 91% of the BOD5 and suspended solids loads, respectively. Although only 13 of 114 site-events had rainfall greater than 5 cm, these few events accounted for more than 50% of the storm runoff measured. There was no baseflow at the upland farm station, and, although pollutants probably leave the site via subsurface flow, quantifying contributions to the groundwater was beyond the scope of this study.

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SECTION 1

INTRODUCTION

The Ware River Study is one of five intensive watershed studies funded by the Chesapeake Bay Program of the U.S. Environmental Protection Agency. In all five basins small catchments are being monitored to determine the quantity and quality of runoff for the major land uses and physiographic features of the Chesapeake Bay drainage basin. The nonpoint source studies in the Ware Basin are the subject of this report.

In the Ware system and in the two Maryland watersheds, estuarine water quality is being studied to determine how it is affected by runoff. The Ware River is relatively clean and, to a certain extent, it serves as the 'control' against which more impacted systems can be compared. The water quality studies of the Ware River estuary are presented in the companion report (Volume 2).

The objective of the nonpoint source studies was to characterize the contribution of various land uses to the nonpoint source loadings to the Ware River in particular, and to Chesapeake Bay in general. This was accomplished through monitoring of runoff flow and water quality at catchments occupied by single land uses. The study sites were chosen such that land uses constituted the major differences among the catchments monitored. However, no two sites could be expected to be exactly the same in terms of physical characteristics which influence runoff, such as soil types, slope, as well as rainfall amount. Thus the approach of EPA was to use mathematical models which simulate these factors in addition land use in order to project loadings from larger watersheds in the Bay occupied by different hydrologic conditions and land uses. The primary objective of the Ware nonpoint source study was to supply the data to be used by modelers for the calibration of nonpoint source generating algorithms (chosen by EPA). As a result, most of the effort of this study was focused on the field collections and organization of data into computer files in a format which can be easily accessed by the modelers. Little emphasis was placed on the interpretation of the loading data at this level of the Baywide nonpoint source effort. Consequently, the results reported here do not attempt to apply the loading data collected from the individual sites to other areas, since such an effort requires consideration of soil types, slope, stage of ground cover, rainfall history, and a number of related factors in addition to land use which can only be examined through the use of sophisticated models which were not available to us. Thus, the reader should be aware that the comparisons made here reflect differences among the sites in toto, and cannot be solely attributed to the land use practices present. This report is intended to provide detailed descriptions of what was done and the methods used so that others can use the data for their purposes. Research findings will be further disseminated through articles in scientific journals.

Unlike the estuarine porton of the study, monitoring at the catchments did not officially begin until August 1979, although considerable effort was expended prior to this time. Work began as early as February 1979 when potential sites were identified with the help of personnel from the Virginia Division of Forestry and the U.S.D.A. Soil Conservation Service in Gloucester County. Permission from land owners was received by the end of March and the first runoff observations were made in April, when recording raingages were installed at two of the sites and grab samples of runoff were collected at all four sites. The amount and quality of data collected increased as equipment was received and installed. Flumes were installed in August along with flow-meters and samplers. Stripchart recorders and additional raingages were installed in January 1980.

SECTION 2

CONCLUSIONS

Although the total rainfall over the study period was relatively uniform throughout the Ware basin, total runoff was substantially different among the four single land use catchments, ranging from 15.4 cm at the well drained agriculture site to 83.4 cm at the forested catchment.

Separation of total runoff into stormflow and baseflow components revealed that the residential catchment produced the greatest amount of stormwater runoff (37.1 cm). The two moderately well drained agriculture sites yielded the least storm runoff.

Baseflow comprised a significant portion (>50%) of the total runoff measured at the residential and forested catchments. The source was probably seepage from the elevated water table, but the supply of this groundwater was not quantified. Baseflow was persistant in the fall and winter of 1979, but ceased during the summer of 1980. It did not recur during the dry winter of 80-81', except at the forested site.

Precipitation conditions were strikingly different during the first and latter half of the study period, with a 33.4 cm surplus above normal precipitation during the first 14 months, and a 37.8 cm deficit during the final 13 months. Runoff from the sites was significantly affected by the drought; over 90% of the total flow measured occurred during the first half of the monitoring period (April 1979 - May 1980).

Storms greater than 5.0 cm (2.0 inches) accounted for only 13 of the total 114 storm runoff events monitored, but yielded over half of the total stormflow measured.

Concentrations of water quality constituents in stormflow were always higher than in baseflow, except for silica. The differences were most pronounced for particulates (an order of magnitude increase), while dissolved constituents increased by a lesser proportion. The stormwater runoff from the farms had the highest total nitrogen, phosphorus, and suspended solids concentrations, while the residential site had the highest carbon (as BOD5), nitrite-nitrate and ammonia values. The forested site generally had the lowest concentrations of constituents.

Baseflow, being a important component of the total runoff at the forested and residential catchments, accounted for a significant portion of the transport of some dissolved pollutants (>50% of nitrite-nitrate), since concentrations in baseflow were similar to those in stormflow. The majority of the total nitrogen and phosphorus loading at all four sites occured as organic forms of nitrogen and phosphorus in storm runoff (about 80% of N and 50% for P). Significant levels of nitrite-nitrate and orthophosphorus in baseflow at the residential catchment may have been due to leaching of nearby septic drainfields into the groundwater, or to fertilizer applications on lawns and gardens within the catchment.

Runoff rates and pollutant fluxes were unevenly distributed among the storm events which occurred during the study. Over 80% of the total runoff and suspended solids loading monitored at the two cultivated catchments occurred during a single storm event. Because of the highly variable loading rate of the individual storms, it was impossible to estimate the runoff and pollutant fluxes for storms which were not monitored. As a result of incomplete records, comparison of total pollutant loading among sites for the study period is not meaningful. Loading rates computed for individual storms do provide a useful comparison of pollutant loading among the sites.

Although there were distinct differences in pollutant concentrations among sites occupied by different land uses, with the runoff from the agriculture sites having the highest and the forested site the lowest concentrations, it was site hydrology which ultimately controlled the total mass of pollutants leaving the catchments. The two row-crop fields which had very similar cultivation schedules and practices had strikingly different pollutant loading rates since the amount of runoff from the upland farm was minimal. Both farm sites had lower loadings than either the residential or forested catchment, except for phosphorus and suspended solids. The loading results illustrate the need to consider factors which affect hydrology, such as soil types, slope, and ground cover, in addition to land use when making pollutant loading projections to other watersheds having similar land use practices.

It is suggested that future watershed studies in coastal areas monitor groundwater processes, since a significant portion of the pollutants generated on a given catchment can be transmitted to recieving waters via a subsurface route. The well drained agriculture site had very low surface runoff loadings, however, it is likely that the over 100 pounds of nitrogen per acre applied each planting season adds dissolved forms of the nutrient to the groundwater, which can then be transported off site to a recieving stream.

Obtaining a continuous rainfall, runoff, and water quality record was not achievable without an adequate set of back-up equipment for the installations at each site. Extreme weather conditions which can occur from year to year can make comparisons of these results with data from other runoff studies tenuous. The highly variable conditions during the two year study period illustrate the need for obtaining long records to determine 'average' annual loadings.

SECTION 3

DESCRIPTION OF THE STUDY SITES

SITE SELECTION - Four small catchments, each occupied by a single land use, were selected based on several sets of criteria. First, the sites had to be occupied by land uses typical not only of the Ware basin, but also typical of the Chesapeake Bay region. It was recommended by EPA that a forested site, a residential site, and two row-crop agricultural sites be monitored. These types of uses occupy about 91% of the land area in the basin and are generally typical of much of Virginia, Maryland and North Carolina (US EPA-EPIC, 1980). Secondly, it was desirable that catchments drain at least 100 acres so that microvariations in the drainage properties would exert minimal variability on the results. The latter goal was not achieved since the topography of the Ware basin precluded drainage from such large areas through a single monitorable waterway. The physical characteristics of the four catchments chosen for study are detailed in Appendix A.

The two row-crop agriculture sites were selected with the help of the U.S.D.A. Soil Conservation Service (SCS). It was suggested that conventionally tilled corn/soybean catchments be monitored since this was the dominant practice in the area (>80% of the local agriculture by area, U.S. EPA-EPIC 1980). Very few farmers use minimum or no-till methods, yet most apply herbicides to control weeds. Soil experts further pointed out the sharp contrast in soil types and topography in the watershed brought about by the presence of the Suffolk Scarp, a geologic landform which strikes through the basin in a southwest-northeast aspect (see Figure 1). They suggested that a useful comparison among agricultural sites would be to monitor areas with contrasting soils since cropping practices are fairly uniform throughout the watershed.

When selecting the two row-crop agriculture sites much attention was paid to soils to ensure representativeness of typical soil types occurring in the region. Fortunately, the Virginia Polytechnic Institute and U.S. Dept. of Agriculture were in the process of resampling and reclassifying the

SAMPLING LOCATIONS

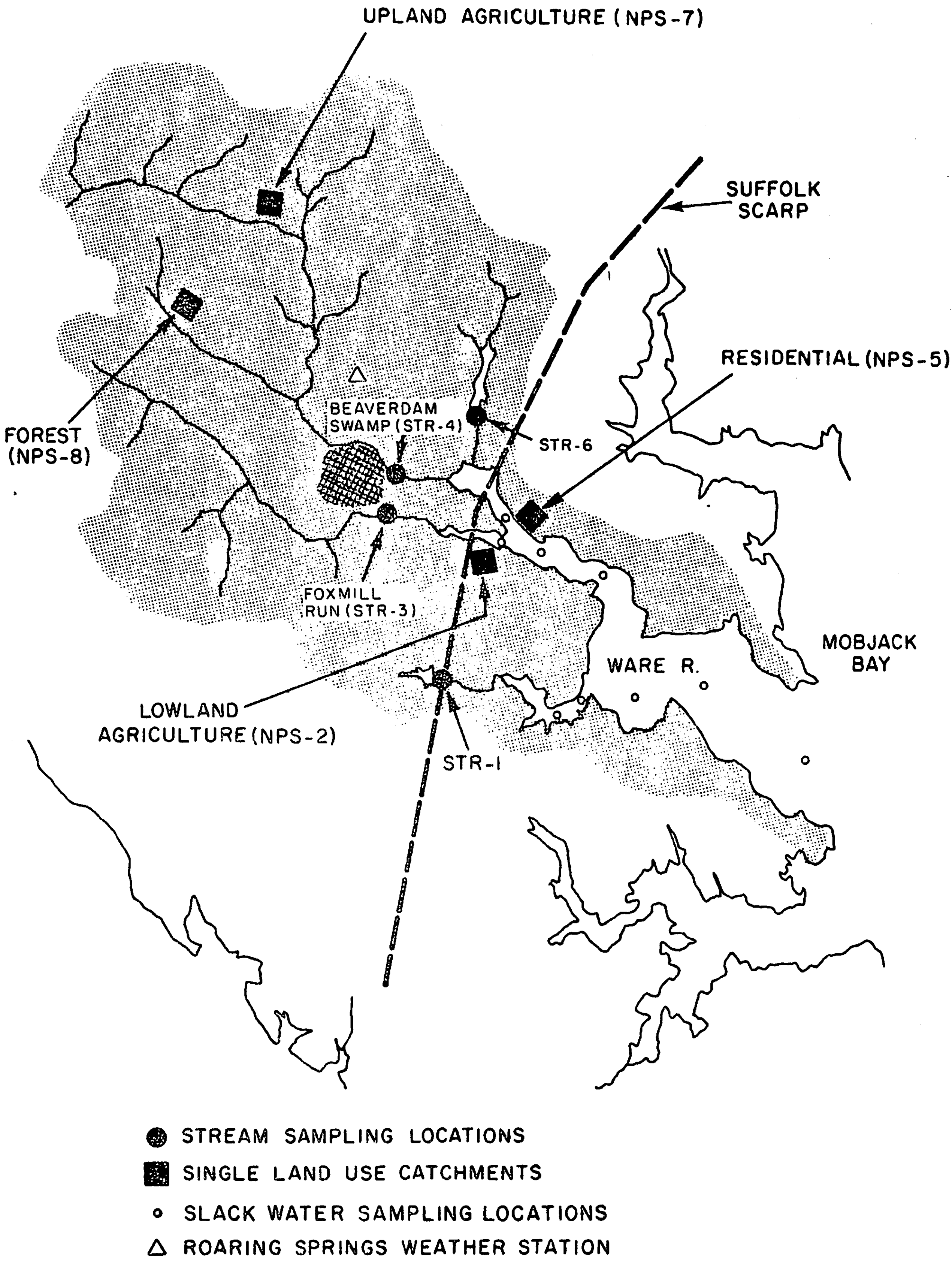


Figure 1. Location of the study catchments, stream sampling stations and weather station in the Ware Basin.

soils of Gloucester County early in 1979. As a result, up to date information on soils was readily available courtesy of the Gloucester office of the SCS prior to selecting the sites. The resulting publication, Soil Survey of Gloucester County Virginia (U.S.D.A.-V.P.I., 1980), is recommended as a data supplement, providing detailed engineering descriptions of the soils occurring throughout the Ware Basin.

Soils were much less a factor in the selection of the forested and residential sites. It was desirable to have an undisturbed forest site rather than one that had been recently timbered, because about 68% of the Ware watershed is unused, mature deciduous-coniferous woodland. Potential study sites and landowners were suggested by the Virginia Division of Forestry office in Gloucester. It was found that nearly all of the watercourses were influenced by beavers, whose impoundments significantly alter runoff flow and quality. Although beavers are indigenous and their dams a typical feature, the forested site finally selected was uninhabitated by beavers. In order to meet this criterion, it was necessary to consider smaller catchments.

In a rural area such as Gloucester County, widely spaced, single family houses are typical, and subdivision housing has been only a recent occurrence. It was suggested that the residential sites be an established subdivision (in existence, say, for 10 or more years), with on site wastewater disposal, specifically, septic tanks and subsurface drain fields. Unfortunately, there were few sites which met these criteria.

The location of the four catchments in the Ware Basin and in relation to the Suffolk Scarp are shown in Figure 1. As can be seen in the figure, two of the sites are eastward of the scarp on the low-lying areas adjacent to the estuary, while the other two sites are in the upper reaches of the watershed where relief is considerably more pronounced. A more detailed description of the physical characteristics of each of the sites follows:

NPS-2, LOWLAND AGRICULTURE - This row crop agriculture catchment site is the largest of the four monitored. Located adjacent to the estuary, the catchment is low and flat, having poorly drained soils.

Approximately 60% of the area is less than 2 meters above the elevation of the monitoring station. The upper reach of the catchment rises on the slope-break of the Suffolk Scarp to an elevation of about 16 meters above the flume (Figure 2). The slight relief and heavy soils result in poor natural drainage and, consequently, man made ditches serve to transmit surface and subsurface runoff. During 1979-80, continuous groundwater flow was observed from November through April, however, during the drought of 1980- 1981 there was no continuous baseflow. Thus the stream here can be described as seasonally continuous and ephemeral.

Although there are six different soils on this catchment, the area is dominated (60%) by heavy, poorly drained sandy loams of the Lumbee and Meggett series (Figure 3). These types occupy nearly all of the land areas eastward of the scarp in Gloucester and adjacent Mathews counties, and are common in North Carolina and the Eastern Shore of Maryland and Virginia. The remaining four soil types occur on the slope-break of the catchment and are the moderately drained series typical of the upper portions of the Ware Basin.

The cultivated portion of the watershed was planted in corn in 1979 using conventional tillage. In the spring of 1980, however, the planting was split with half the catchment planted in soybeans and half in corn. The crops were then rotated for the 1981 planting. Figure 2 delimits the two fields cultivated during 1980-1981, and Table 1 provides a complete list of planting, harvesting, and fertilizer application rates and dates for the three growing seasons encompassing the monitoring period.

NPS-5, LOW DENSITY SINGLE FAMILY RESIDENTIAL - The residential catchment is also located adjacent to the estuary, roughly opposite NPS-2 on the northern shore of the river. Also located on the down side of the scarp, it has an average elvation of 5 meters above mean sea level and slopes of less than 1%. The mixture of soils here are also heavy and poorly drained, but these are less typical than those at NPS-2. The subdivision is one of few established residential areas in the watershed. Most clustered housing in the basin are near Gloucester Village and served by the local sanitary district. Seven single family homes occupy the catchment, and domestic wastes are discharged to subsurface drainfields. There are no sewers or storm sewers; all of the homes are within a few hundred meters of the shoreline, and runoff and groundwater flows are transmitted via a series of interconnected roadside ditches (Figure 4). Due to the low elevation and slight topography, continuous groundwater flow occurs during late fall through early spring, but, like NPS-2, were not observed during the dry 1980-81 period.

NPS-7, UPLAND AGRICULTURE - The second row-crop site is located westward of the scarp at an elevation of about 15 meters above sea level. The medium sized drainage catchment is composed of a mixture of moderately well drained soils which are light and sandy in texture. Because of steep slopes (2-6%) and light soils, the erosion potential is moderately severe. The owner installed grassed waterways during the mid-1960's as a conservation practice. The elevation and moderately permeable soils result in a much lower water table; no baseflow has been observed here since the site was selected in March 1979. The flow is entirely ephemeral, and runoff events are infrequent and short lived.

The catchment was planted in corn in 1979 and soybeans in 1980 using conventional cultivation methods. For the 1981 corn rotation however, the farmer used a no-till method because he found it required fewer trips over the fields and thus saved his fuel costs. Tillage, planting, and fertilizer dates at this site are listed in Table 2. Soils groups and elevations are depicted in Figures 6 and 7.

NPS-8, UNDISTURBED MIXED FOREST - A large number of potential forested sites were available because most of the Ware Basin is occupied by this land use. The site chosen was selected primarily because it was unimpacted by beavers, easily accessible, and in close proximity to NPS-7. Choosing a site in the upper reaches of the watershed yielded sites at either end of the Ware Basin, with two in the upland and two in the lowland portions of the study area.

The site has gentle and variable slopes but somewhat heavy soils which are unlike the light, sandy soils of the upland agriculture site (Figures 8 and 9). There is a continuous baseflow at this site due to a flat swampy area at the head of the catchment which detains water originating from runoff and subsurface sources. Groundwater has also been observed entering the stream at various points (springs) along the watercourse. Flow at the monitoring station was continuous from March 1979 until the especially dry summer of 1980 caused both the swamp and groundwater springs to dry up. Baseflow was also observed here during the winter of 1980-81.

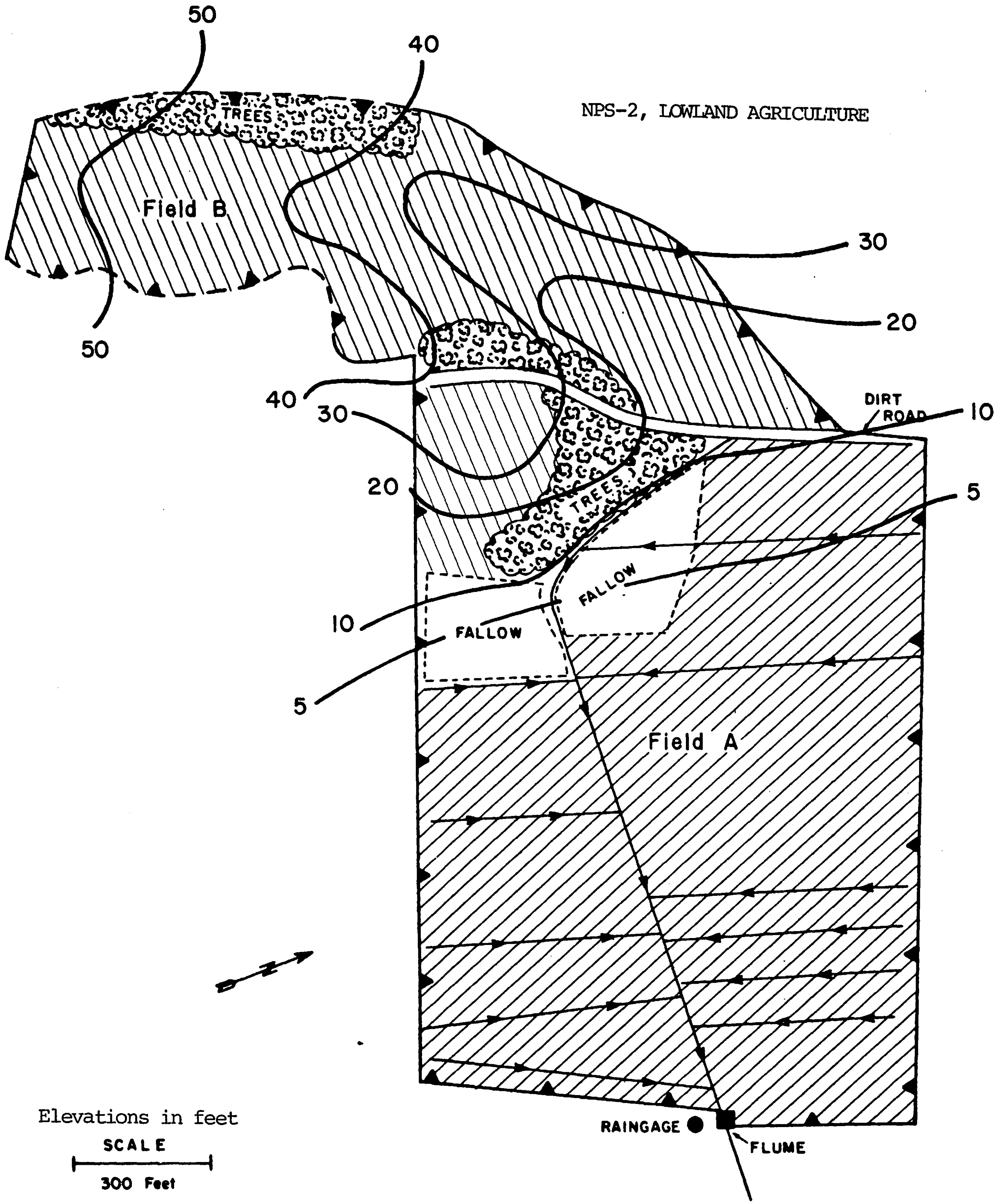


Figure 2 . Topography and cover of the lowland agriculture catchment, NPS-2.

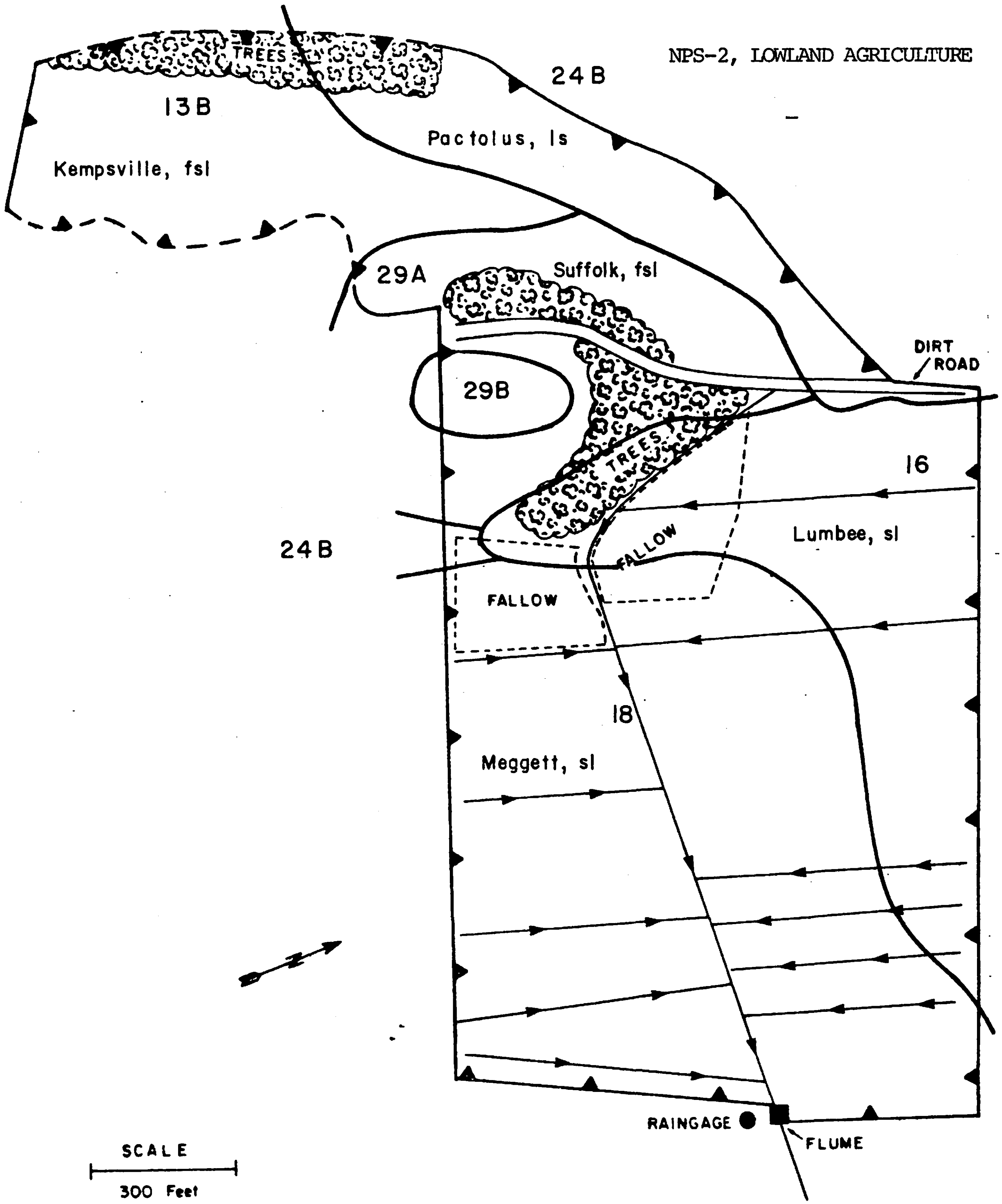


Figure 3 . Soil units at the lowland agricultural catchment, NPS-2.

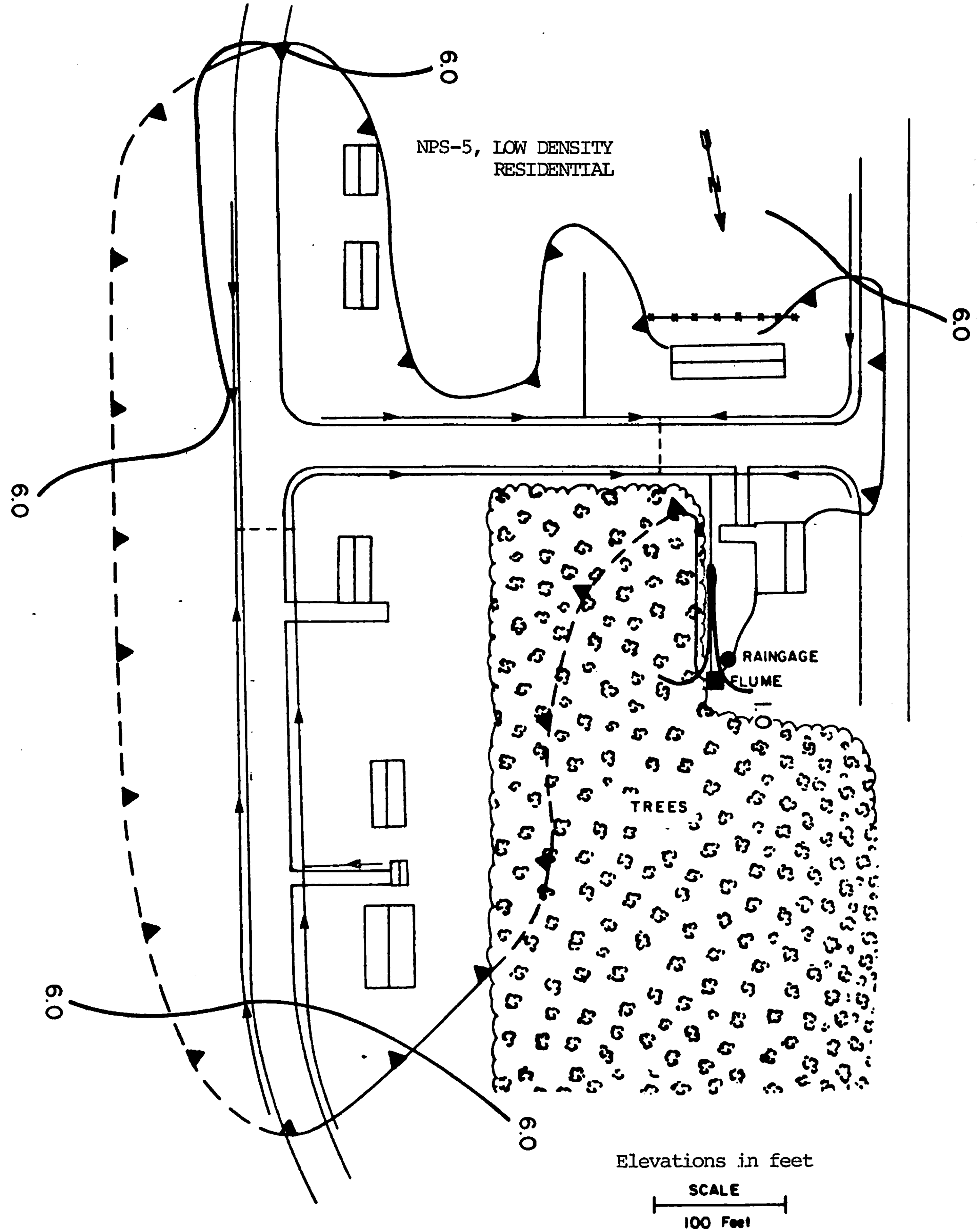


Figure 4 . Topography and cover of the low density residential catchment, NPS-5.

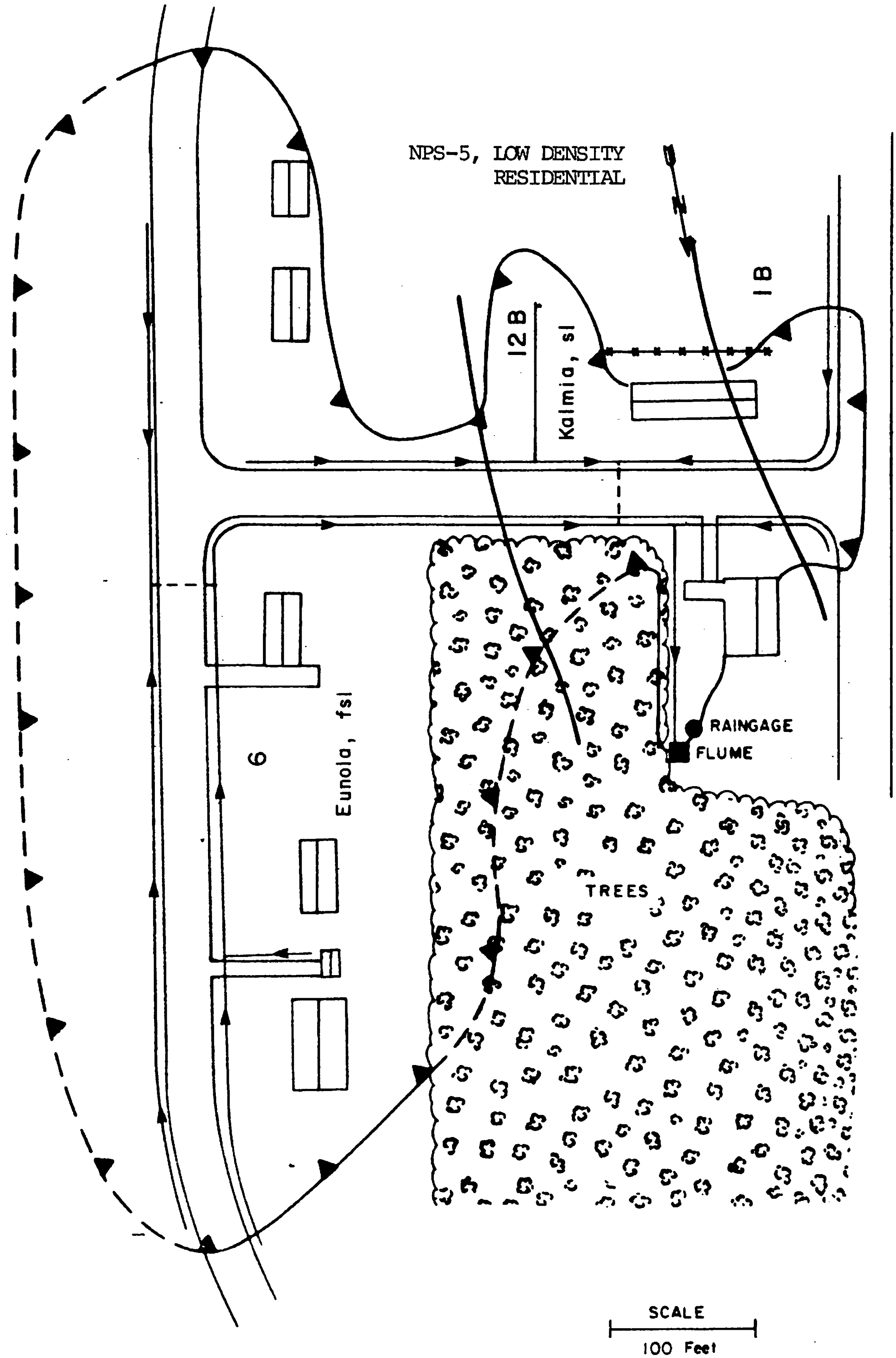


Figure 5 . Soil units at the low density residential catchment, NPS-5.

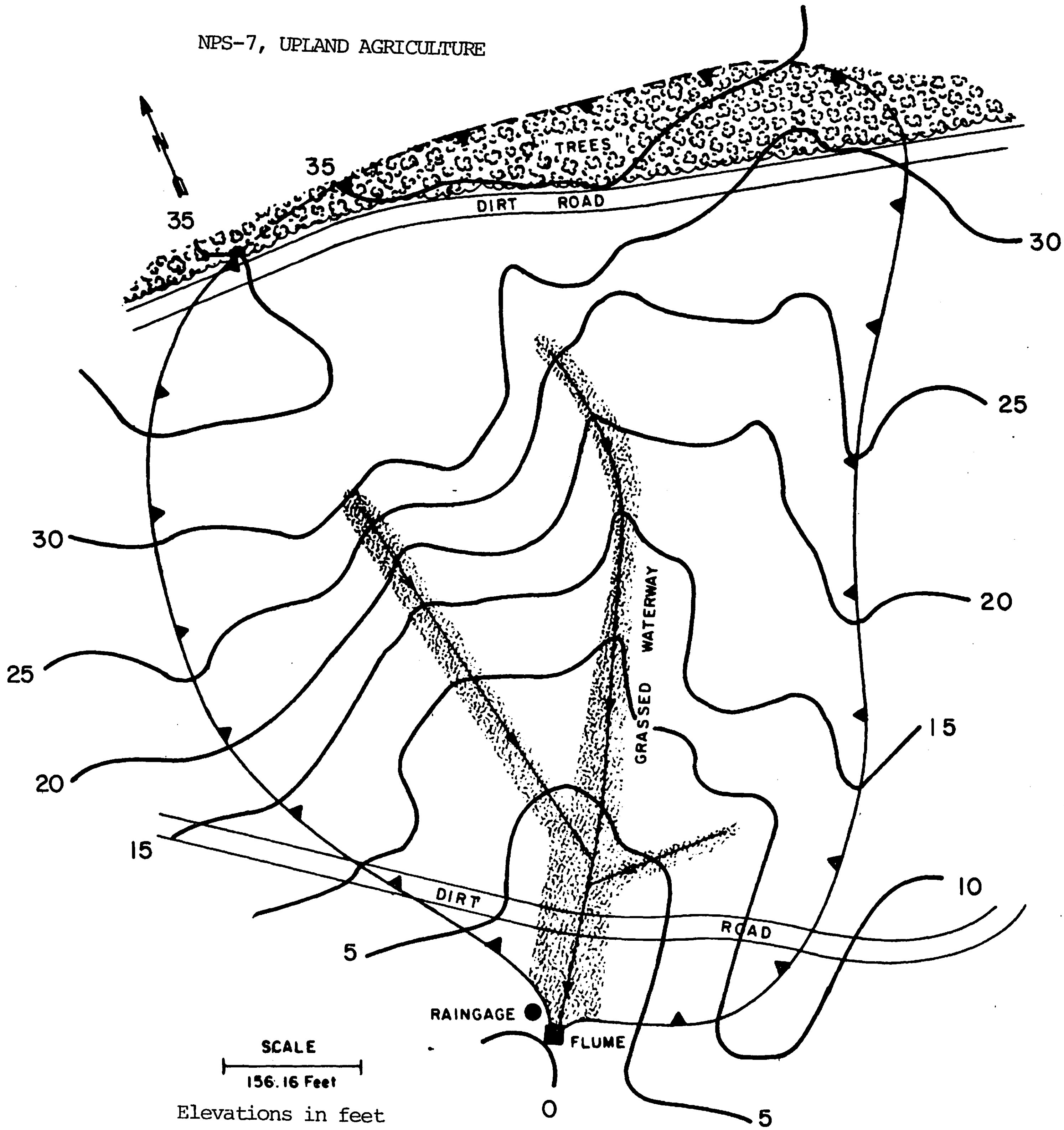


Figure 6. Topography and cover of the upland agriculture catchment, NPS-7.

NPS-7, UPLAND AGRICULTURE

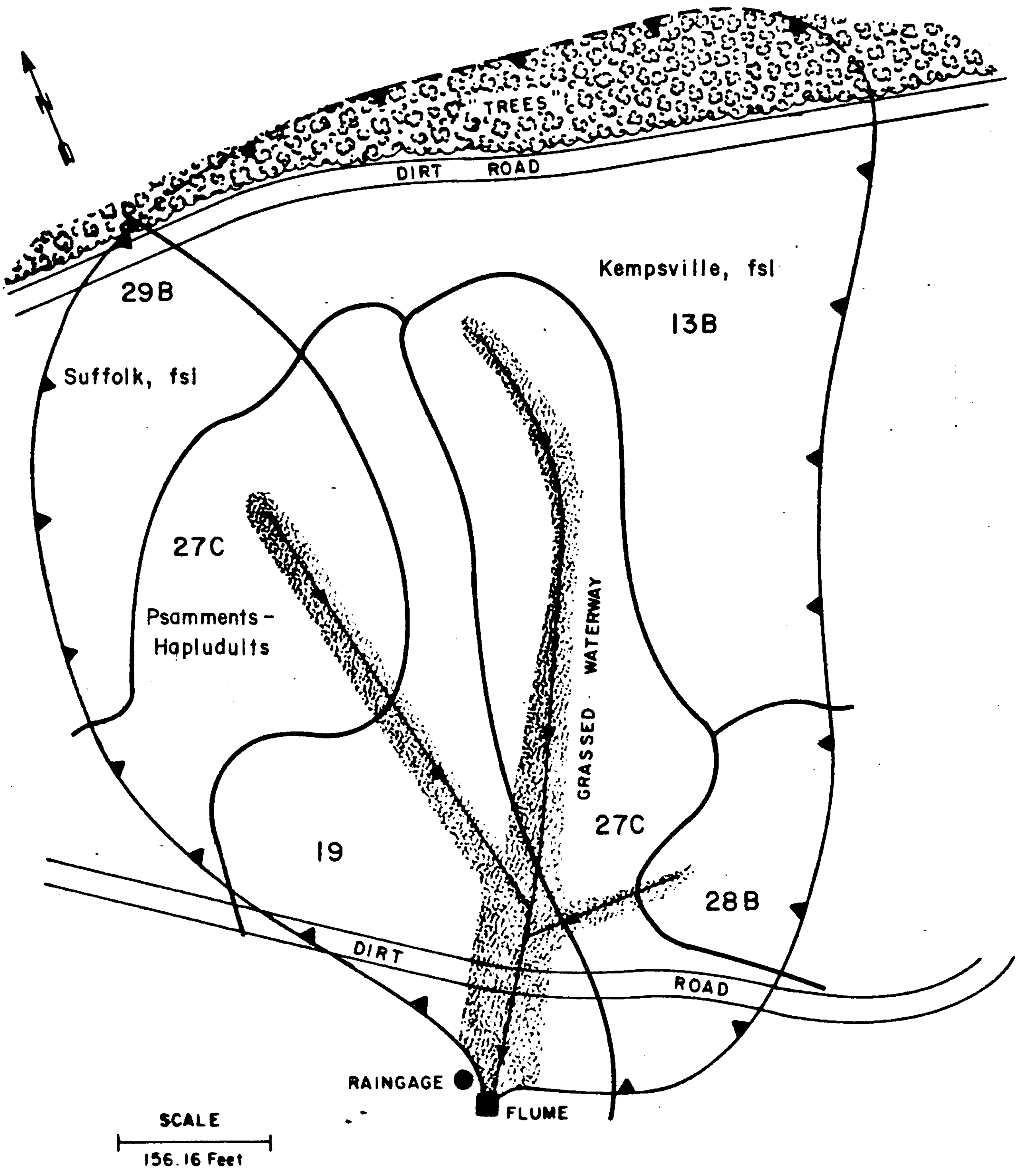


Figure 7. Soil units at the upland agriculture catchment NPS-7.

NPS-8, UNUSED MIXED FOREST

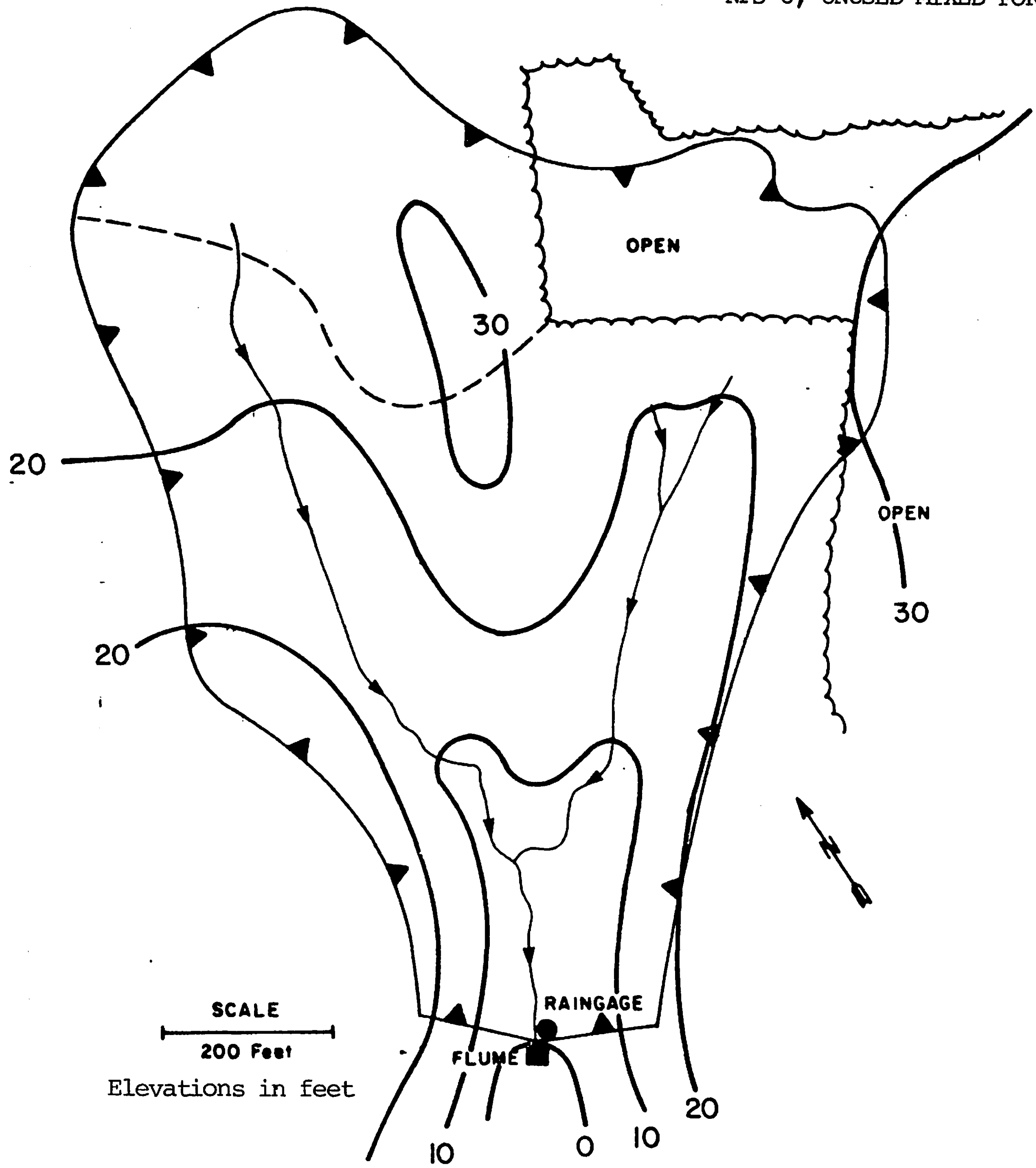


Figure 8. Topography and cover at the unused mixed forest catchment, NPS-8.

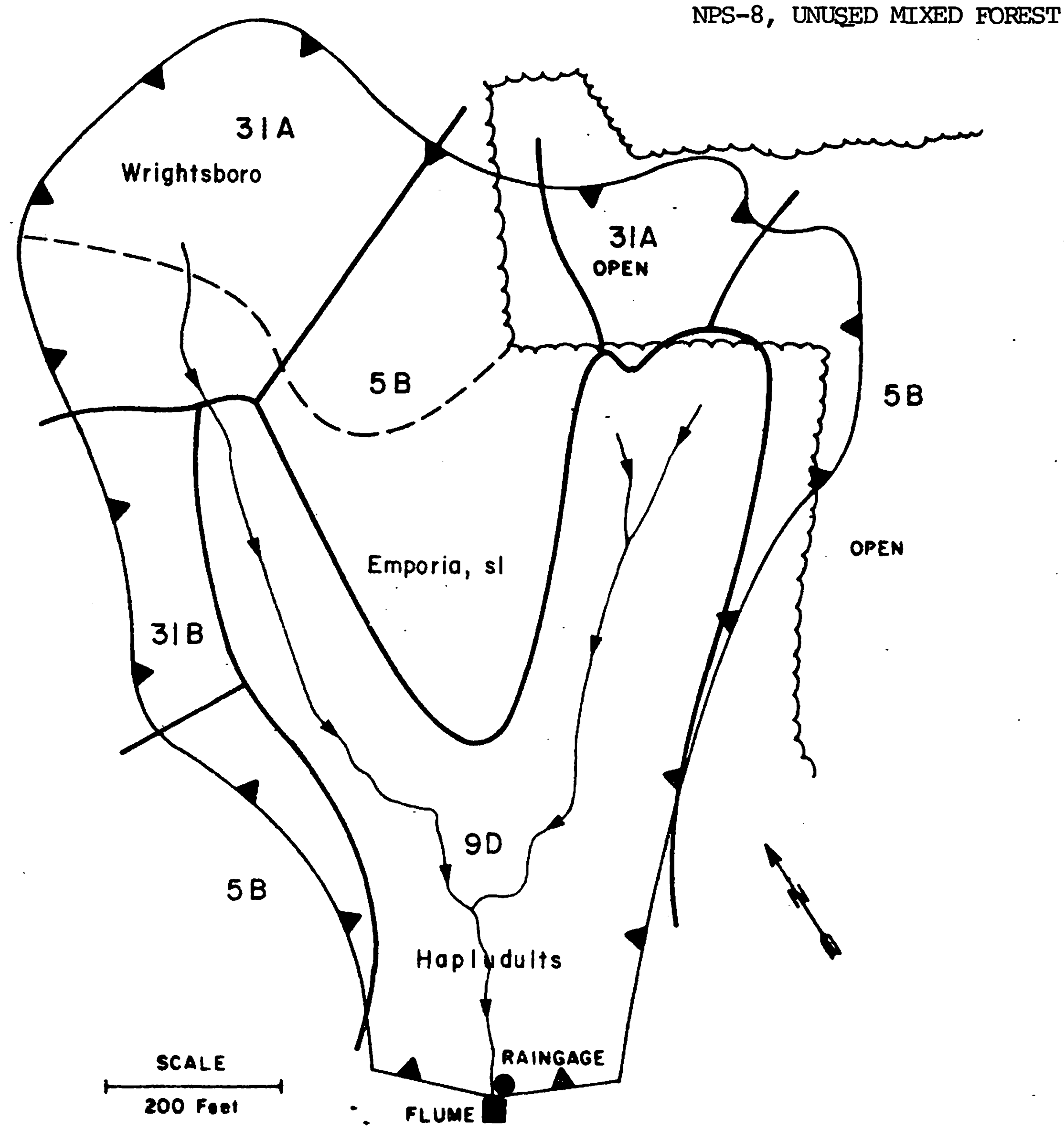


Figure 9. Soil units at the unused mixed forest catchment, NPS-8.

TABLE 1. TILLAGE PRACTICES, FERTILIZER APPLICATIONS, AND STAGE OF GROWTH DATA, NPS-2, LOWLAND AGRICULTURE

1979 Cropping Season

20 - 23 April '79	100% of cultivated area tilled. Fertilizer applied at a rate of 1000 lbs./acre; composition: 2-6-12 percent N (ammonium nitrate), P (superphosphate), and K (muriate of potash). Incorporated by disking. Entire cultivated area planted in corn.
14 - 20 October '79	Corn crop harvested, stubble left on fields.
20 November '79	Entire cultivated area tilled, 8-8-8 fertilizer applied at a rate of 900 lbs./acre and incorporated by disking.
24 November '79	Entire cultivated area planted in winter wheat cover crop.

1980 Cropping Season

NOTE:	The wheat crop planted in November of 1979 was a success in the upper 27% of the culvated area (Field B), while the lower 55% of the wheat planted (Field A) failed to grow, probably due to the excessive wet conditions which occurred in these lowlying areas during the fall of '79. As a consequence, the farmer re-planted corn on the lower field and left the upper (Field B) in wheat until planting with soybeans early in the summer of 1980. From this spring on, the watershed became divided, having two separate crops at different stages of growth.
15 March '80	Field B wheat fields fertilized with 900 lbs./acre 8-8-8.
7 May '80	Field A tilled, fertilized using 2-6-12 at a rate of 1000 lbs./acre, and planted in corn.
19 May '80	Corn sprouts 6" tall (Field A).
2 June '80	Corn 12" tall.
13 June '80	Corn 20" tall.
17 June '80	Winter wheat harvested from Field B. Straw approx. 6-9" tall left standing.
24 June '80	Corn 30-40" tall (Field A).

TABLE 1. NPS-2, LOWLAND AGRICULTURE, CROPPING PRACTICES (Continued)

1980

3 July '80	Corn 60" tall.
14 July '80	Corn 84" tall. Field B wheat stubble tilled under, left bare.
18 July '80	Corn 84" tall.
week of 20 July	Field B disked and planted with soybeans, no fertilizer applications.
6 August '80	First ears appearing on corn plants, 90" tall (Field A). Soybean plants 8-12" tall (Field B).
29 August '80	Soybeans 12-18" tall (Field B).
6 September'80	All corn harvested, stubble approx. 8"tall left on field (Field A).
2 October '80	Grass developing on corn stubble.
6 October '80	Corn fields (Field A) disked.
10 October '80	Winter wheat planted on Field A, no fertilizer applications. Soybeans on Field B are 25-30" tall, appear yellow and dry.
20 October '80	Winter wheat established, approx. 3-4" tall (Field A).
13 November '80	Field B soybeans harvested, tilled.
18 November '80	Field B planted with winter wheat.
5 December '80	Wheat growing, both fields.

1981

31 March '81	Field B wheat harvested and plowed. Field A wheat fertilized with 8-8-8 at 900 lbs./acre. Wheat approx. 8" tall.
18 April '81	Field B plowed and planted with corn, 2-6-12 applied at 1000 lbs./acre.
25 May '81	Corn 8" tall (Field B). Wheat 12" tall (Field A).

3 June '81	Wheat 18" tall and yellowing (Field A). Corn 20" tall (Field B).
6 July '81	Wheat harvested, soybeans planted, no fertilizer applications (Field B).
21 July '81	Soybeans 12" tall (Field B).

TABLE 2. TILLAGE PRACTICES, FERTILIZER APPLICATIONS, AND STAGE OF CROP GROWTH DATA, NPS-7, UPLAND AGRICULTURE

<u>1979 Cropping Season</u>

10 - 15 April '79	100% of cultivated area tilled. Fertilizer applied at a rate of 1000 lbs./acre; composition: 2-6-12 percent N (ammonium nitrate), P (superphosphate), and K (muriate of potash), and incorporated with disk harrow. Entire cultivated area planted in corn.
4 October '79	70% of corn harvested, stubble approx. 8" tall left on field.
14 October '79	Remaining 30% of corn crop harvested, stubble left.
12 December '79	Entire cultivated area tilled. Left unplanted over winter '79-80.

<u>1980 Cropping Season</u>

28 March '80	100% area tilled, 2-6-12 fertilizer applied at a rate of 400 lbs./acre and incorporated with disk harrow.
9 May '80	100% area tilled.
3 June '80	Planting day. 100% planted with soybeans.
10 June '80	Soybeans 1-2" tall.
24 June '80	Soybeans 6" tall.
3 July '80	100% of cultivated area tilled between bean rows. Grassed waterways cut to approx. 6" tall.
15 July '80	100% of cultivated area tilled between soybean rows.
18 July '80	Soybeans 12" tall. Grassed waterways 12-18" tall.
6 August '80	Soybeans 15-20" tall.
29 August '80	Soybeans 30" tall. Grassed waterways cut to 6" tall.
9 September '80	Soybeans 30" tall. Waterways 24" tall.

TABLE 2. NPS-7, UPLAND AGRICULTURE CROPPING PRACTICES (Continued)

1980	
19 September '80	30" soybeans, leaves turning yellow and dropping due to dry conditions.
3 November '80	Nearly 80% of the soybean leaves have fallen off.
13 November '80	Entire crop of soybeans harvested, yield: 20 bushel per acre. Stuble left on field.
5 December '80	Stubble re-cut to approx. 6" tall, remained on field for winter of '80-81.
1981 Cropping Season	
18 - 19 April '81	Planting day. Farmer used no-till practice for the first time. 2-6-12 fertilizer applied at a rate of 1000 lbs./acre plus 125 lbs./acre of Year Round 30 (30% nitrogen). Ground was not broken. Corn planted on top of soybean stubble.
1 May '81	Corn seedlings about 3-6" tall
15 May '81	Corn 8" tall.
1 June '81	Corn 12" tall.
18 June '81	Corn is 30" tall.
16 July '81	Hay in grassed waterways cut, corn is 72-96" tall.

SECTION 4

MATERIALS AND METHODS

NPS CATCHMENT MONITORING

INSTRUMENTATION - An H-type flume for channelling and gaging runoff flows was installed at each site. These were built according to specifications outlined in A Manual for Research in Agricultural Hydrology published by the U.S. Department of Agriculture (1979 ed.).

H-flumes have an advantage over weirs in that they require little head loss in the watercourse, an important feature because of the topography encountered in portions of the Ware Basin. Flumes were fashioned out of sheet metal and each had to be large enough so that during large, infrequent storms the capacity of the flume would not be exceeded, yet small enough so that runoff from the many small storms could still be detected. A diagram of the typical site installation showing flume, flowmeter, raingage, and water sampler appears in Figure 10.

Runoff monitoring at the flumes was accomplished using an automatic sampling and flow recording system manufactured by Instrumentation Specialities Corporation, Inc. (ISCO). The flowmeter (ISCO model 1530) is a solid-state device which measures water height in the flume and converts this level to an instantaneous flow rate which is then integrated over time. The meter provides a continuous output of instantaneous rate (cu.ft/sec), and has been equipped with an interface to provide a continuous trace on a stripchart recorder. The flowmeter also is equipped with a counter which totalizes the integrated flow in units of cubic feet.

When used in conjunction with the ISCO model 1580 automatic sampler, the flowmeter controls the sampling cycle so that samples are collected at equal intervals of total flow. The sampler delivers an aliquot of sample to a container each time it is triggered. The result is a single, flow proportioned composite sample whose chemical composition is representative of the flux of material during the runoff event. Depending on the amount of runoff, the sampler could collect up to 150 aliquots during a single event. The sampler intake was mounted in a trough under the spill-way of each flume to obtain a vertically mixed, representative sample. Within 25 ft. of each flume, a tipping bucket raingage sensitive to the nearest 0.01 inch was installed. The gages are of the model 2500 series supplied by Sierra Environmental Products of Berkeley, California.

DUAL PEN STRIPCHARTS - A requirement of the initial work plan was that the rainfall record and flow rate record be traced on a single stripchart. In this way the two records would be time coordinated thereby eliminating errors brought about by individual chart drives operating separate flow and precipitation recorders. Such errors would complicate modelling efforts. Commercially available interfaces which convert rainfall counts to an analog signal were costly. Therefore the selected approach was to take a flow record, which was a continuous analog trace, and combine it with the digital counts of the raingage. The recorder selected, Rustrak Model 388/392-8, had an analog channel for flow records and a series of event channels for precipitation. The raingage signal was conditioned to provide tick marks on three event channels at increments of 0.01, 0.10 and 1.00 inches of precipitation. This was accomplished by building a solid-state device which counts pulses from the raingage, splits the output and signals the recorder for each hundreth, tenth, and full inch of rainfall.

The device, which we refer to as a decade counter, is also equipped with an L.E.D. display of the total accumulated rainfall measured to the nearest 0.01 inch for the purpose of verifying the stripchart record. Because of a delay in delivery of the Rustrak recorders, this equipment was not installed until January of 1980. Tube raingages were installed at each site in May of 1980 to further verify the rain record.

Although the recording gages were not installed until 1980, auxilliary recording gages had been installed at NPS-2 and NPS-7, providing a record of rainfall beginning in April 1979. These gages are also of the tipping-bucket

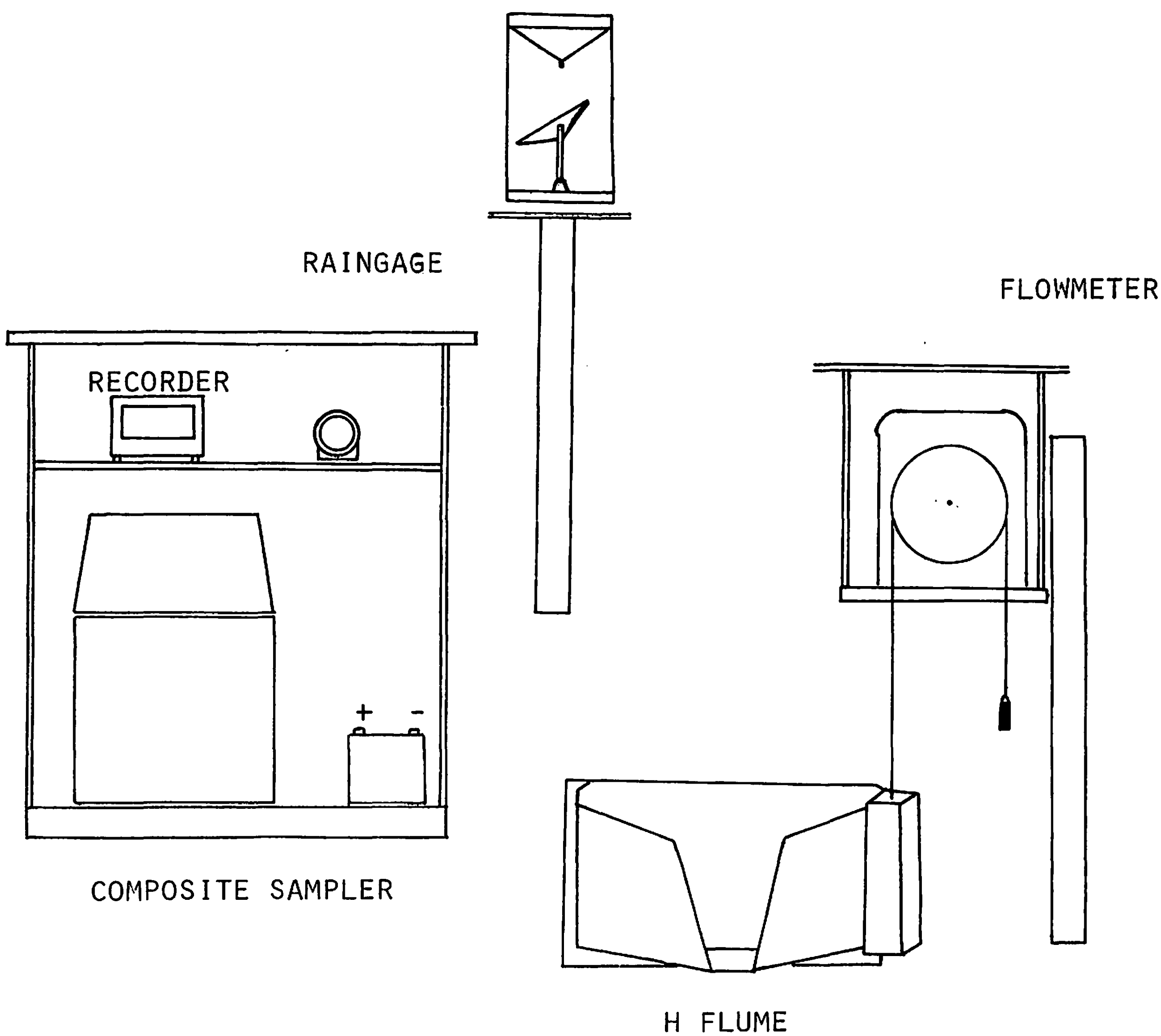


FIGURE 10. Instrumentation at Single Land Use Runoff Monitoring Stations.

type, recording at a sensitivity of 0.01 inch. The placement of the gages near the estuary (NPS-2) and in the upper reaches of the Ware Basin (NPS-7) provided the best coverage of the watershed that could be achieved with only two instruments. The remaining two ungaged catchments (NPS- 5, NPS-8) were within 3 kilometers of these gages.

RUNOFF MONITORING PROCEDURES - The field procedure at the catchments changed throughout the study period as more and more equipment was received and installed. Initially, no flow measurements were available, and only rainfall data and manually collected grab samples of runoff for water quality analysis were collected prior to the fall of 1979, when flumes, flowmeters and composite samplers were installed. At this time, monitoring of individual storm runoff volumes and pollutant loads began, as well as continuous monitoring of baseflow volumes at those sites where baseflow was present. In January 1980 the dual-pen stripchart recorders and tipping-bucket raingages were installed at each site. Table 3 summarize the parameters monitored during the various phases of equipment installation.

Table 3. Summary of Rainfall, Runoff Flow and Runoff Quality Monitoring at the Single Land Use Catchments During the Study Period.

Approximate Dates	Parameters
April 1979 - August 1979	Precipitation (NPS2 and NPS 7 only) Water Quality (grab samples, all NPS sites)
September 1979 - January 1980	Precipitation (same as above) Total flow (all NPS sites) Water Quality (composite samples)
February 1980 - August 1981	Precipitation (all sites) Total flow Instantaneous flow rate (stripchart) Water Quality (composite samples)

A detailed description of the storm runoff sampling and data collecting procedures that were followed in the field are provided in Table B1 in Appendix B. Site visit procedures are outlined in Table B2 and the maintenance schedule in Table B3.

The instrumentation system resulted in continuous monitoring of flow and rainfall at each catchment. A criteria had to be established for collecting water quality samples since not all storms could be monitored for water quality, nor could samplers be turned on at the slightest showing of a rain cloud. A study of precipitation in the Chowan Basin (Humenik, et al., 1977) suggested a criteria of 50% probability of rain before samplers were activated. It was found that this level provided a reasonably succcessful return for the effort, resulting in 18 storms greater than 0.50 inch, and six storms above 1.00 inch during the course of a year. The samplers were turned on no more than 18 hours prior to storms. Calculations determined that baseflow sampled during the period prior to rainfall was usually insignificant, accounting for less than 2% of the total flow sampled during the entire storm event. On occasions when the sampler had been turned on for more than 18 hours, and no runoff occurred, the site was again serviced and a new sample container installed. At this time, a temperature reading was made and a grab sample for dissolved oxygen was collected since representative values for these parameters could not be achieved from the composites. All other water quality constituents were measured from the composited sample.

In additon to sampling runoff, samples of baseflow were collected to estimate the contribution of nonstorm flow to the annual loading rate. These were collected at the time of slackwater sampling in the estuary, except during the summer months when the watercourses were dry.

WATER QUALITY PARAMETERS

Runoff samples were analyzed according to proceedures outlined in 'Methods for Chemical Analysis of Water and Wastes' (U.S. EPA, 1979).

The folowing constituents were measured in both baseflow and storm runoff samples:

Parameter	Storet No.
Total non-filterable residue, mg/1	00530
Total organic carbon, mg/1	00680
Total phosphorus, mg/1	00665
Dissolved orthophosphorus, mg/1	00671
Total Kjeldahl nitrogen, mg/1	00625
Diss. total Kjeldahl nitrogen, mg/1	00623
Diss. nitrite-nitrate nitrogen, mg/1	00631
Dissolved ammonia nitrogen, mg/1	00608
Dissolved silica, mg/1	-
Biochemical oxygen demand, mg/1	00310
Alkalinity, mg/1 as carbonate	00410
pH	00403

From these measurements, the various organic fractions of nitrogen and phosphorus were computed as follows:

Organic nitrogen = TKN - Dissolved Ammonia

Total nitrogen = TKN + Dissolved nitrite-nitrate

Organic phosphorus = Total Phos. - Orthophosphorus

THE WEATHER STATION

The Weather station was located at Roaring Springs Farm near sampling station STR-9 on Beaverdam Swamp. This site was chosen primarily because it was close to the centroid of the watershed (see Figure 1). Climatological parameters to be monitored were not established formally until March, 1980, consequently, continuous monitoring of temperature, humidity, evaporation, and wind did not begin until May of 1980.

The following parameters have been monitored:

Air temperature (oC), continuous
Relative humidity (%), continuous
Precipitation (in.), total and continuous
Evaporation (in.), semi-weekly
Wind (miles), semi-weekly

SECTION 5

RESULTS AND DISCUSSION

PRECIPITATION: APRIL 1979 to JULY 1981

The most notable feature of the study period from April 1979 - July 1981 is the progression from a rainfall surplus to a rainfall deficit. Abnormally wet conditions prevailed during the first half of the study period and drought during the second. The National Weather Service maintains 27 stations in Virginia east of the fall line which constitute their "Tidewater Division". Record high rainfalls were recorded at these stations during May, September and November 1979, while record minimum monthly precipitation occurred during June, August and September 1980 and January 1981. Thus, 7 out of the 27 months of the Ware field program yielded record maximum or minimum monthly precipitation in the Tidewater Division. During the first 14 months there was a 33.4 cm surplus of rainfall compared to the average of 128.8 cm expected for Tidewater (based on data 1940-1970), while during the latter 13 months there was a 37.8 cm deficit in rainfall. As a result of the drought, Beaverdam Swamp reached zero discharge in late July 1981, the first time this has occurred since 1953 (U.S.G.S., 1981).

Overall the Ware River basin appears to receive less rainfall than much of Tidewater Virginia. Isopleths of annual rainfall for the state (Figure 11) show that in the Coastal Plains, annual precipitation ranges from 107 cm to 127 cm. The rainfall for the Ware Basin is near the lower end of this range. Thus one would expect that the average for Tidewater would be higher than that measured within the Ware watershed.

The precipitation data collected during the 27 month period from April 1979 - July 1981 suggests that rainfall is unevenly distributed within the Ware basin during all seasons of the year. The two gages placed at either end of the watershed yielded different results, which were later substantiated by the placement of additional gages in January of 1980. The seasonal data collected are summarized in Table 4. Remarkably, however, the total rainfall at the end of the project was nearly equal at the upland and lowland sites. The Ware Basin average rainfall was lower than the Division average by about 6%.

There is an apparent gradient in precipitation between the southeast (lowland) and nothwest (upland) portion of the watershed. During the spring and summer seasons, the upper portion of the basin received more rainfall than the lowland areas. During the fall and winter, the lowland received more. The difference between areas is somewhat greater during the summer months, however, and surpasses those differences which occur in fall and winter. The annual totals in the Mobjack Bay area increase as one traverses in a southeast to northwest direction as illustrated in Figure 11. Interpolation from the map results in an expected annual average difference of about 2 cm between upper and lower portions of the Ware. The Fall-Winter and Spring-Summer trends were more prounounced during 1979-80, prior to the drought. Rainfall in the Ware Basin in relation to the Division average for each month during the study period are plotted in Figure 12.

TABLE 4. Seasonal Rainfall at the NPS sites (cm)

	Lowland		Upland	
	NPS-2	NPS-5	NPS-7	NPS-8
Spring '79	30.9 cm		32.4 cm	
Summer '79	50.8		58.6	
Fall '79	25.8		22.7	
Winter '80	27.4	23.3	23.4	21.4
Spring '80	17.2	15.0	24.1	25.4
Summer '80	20.2	19.3	24.5	33.6
Fall '80	24.6	21.3	17.3	17.0
Winter '81	16.3	10.8	11.6	11.6
Spring '81	21.7	20.2	20.7	24.9
Totals	234.9		235.3	

Total for the Tidewater Division (April 1979 to July 1981): 249.6 cm

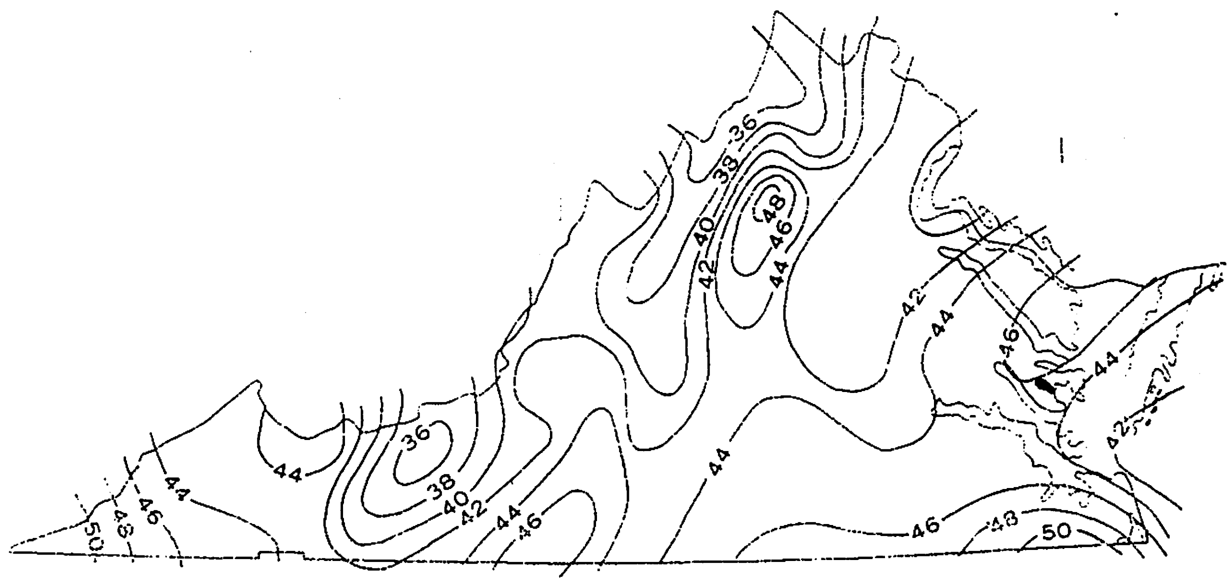


FIGURE 11. Distribution of Average Annual Rainfall (inches) in Virginia (Source: U.S. Environmental Data Service).

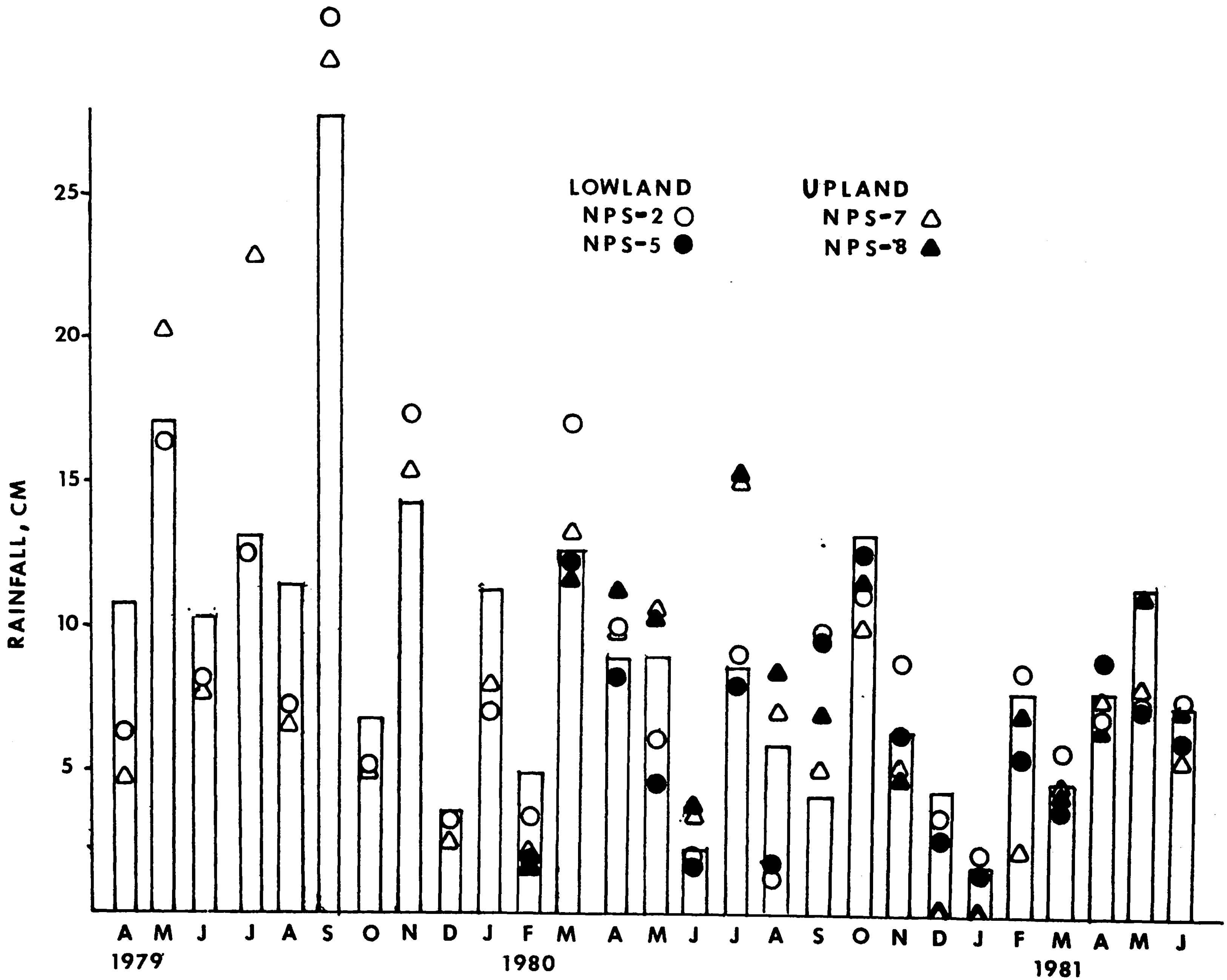


Figure 12. Average Precipitation for the Tidewater Division and Actual Rainfall at the Four NPS Catchments, April 1979 - July 1981.

HYDROLOGY OF THE STUDY SITES

In this section, the rainfall and runoff data are discussed in order to compare the hydrological characteristics of the study sites. Since the beginning of October, 1979, flow monitoring at the single land use catchments has been continuous although, on occasion, interrupted by short intervals ranging from a few hours to several days when flowmeters malfunctioned, batteries went dead, or the record was obscured by occurrences such as a debris clogged flume. As a result, composite samples of some rain events were lost or regarded as not representative and discarded. The data interpreted in this section of the report incorporates only those storms which are known to have complete and accurate flow and rainfall data. These are listed for each site in Tables C1 - C4 in Appendix C. The water quality composite and grab samples collected during storms will be discussed in an another part of this section. Although not all of the storms listed were composite sampled, the rainfall and runoff data from those which were not still provide insight on the hydraulic characteristics of each catchment. The number of runoff episodes observed at each site during the 22 month period suggests that the two agriculture sites produce less flow than either the forested or residential catchments.

Figures 13, 14, 15, and 16 depict the cumulative rainfall and runoff at each site for the study period as well as sediment yield (per ha) using the data from the events that were successfully composite sampled. It should be pointed out that sediment loading was somewhat correlated with the loading of nitrogen, phosphorus and BOD5, so the plot of sediment yield can also be considered as representative of the loading of these important pollutants.

A pronounced feature of the graphs are the drought conditions which began in June of 1980. Continuous baseflow ceased and never returned during the winter as in 1979-80, indicating that the soil mositure and groundwater levels were significantly reduced due to the lack of rainfall. As a result, there were very few runoff episodes at any of the sites after the summer of 1980. On the average, only 32% of the runoff events observed occured in the second half of the 22 month monitoring period (after June 1980). And, nearly 95% of the total flow was recorded during the first half when rainfall was above average (Table 5). These figures illustrate the need for long term monitoring of nonpoint source processes since conditions can vary widely over short periods of time.

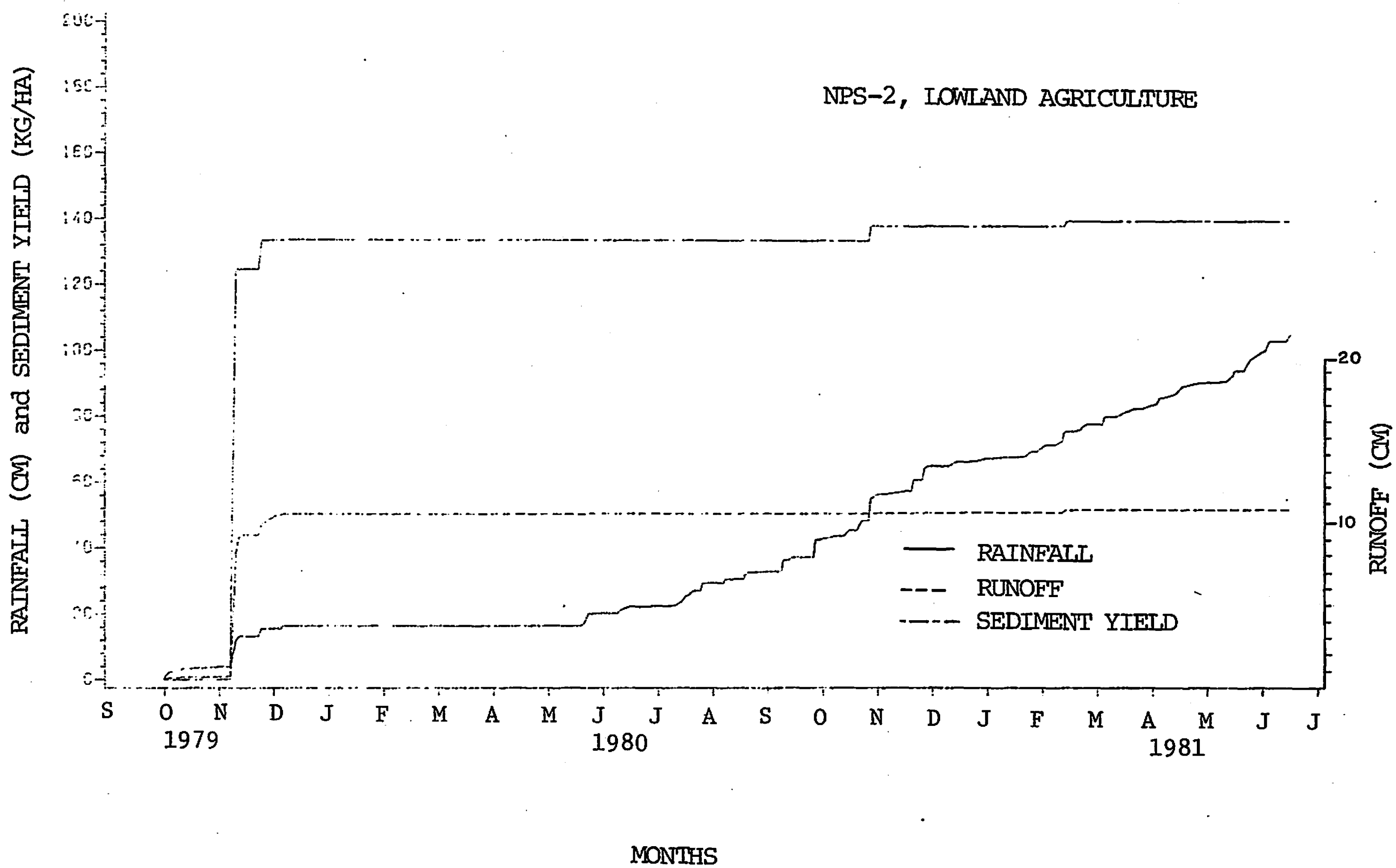


Figure 13. Cumulative rainfall (cm), and sediment yield (kg/ha) at the lowland agriculture catchment, NPS-2.

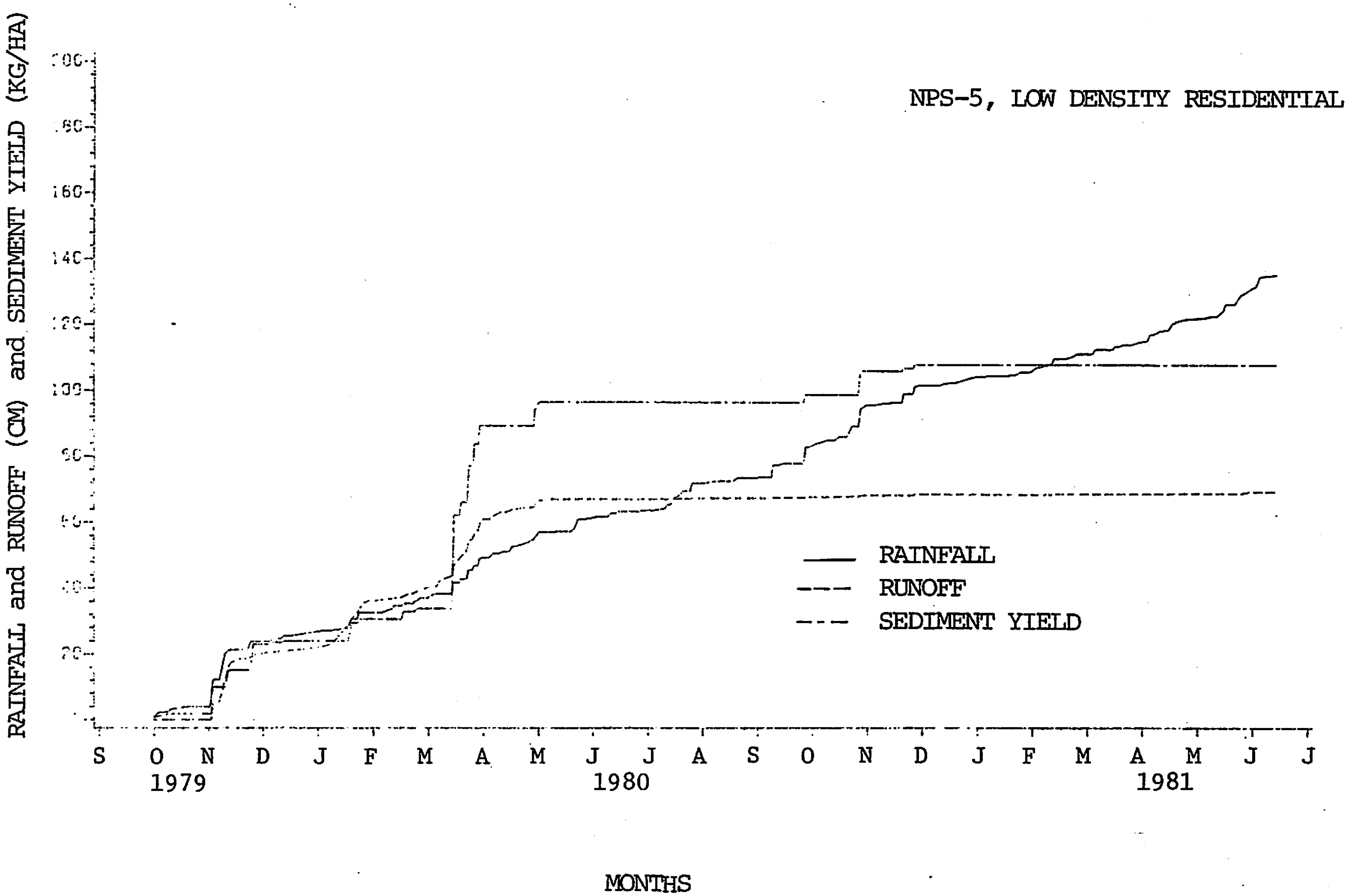


Figure 14. Cumulative rainfall (cm), and sediment yield (kg/ha) at the low density residential catchment, NPS-5.

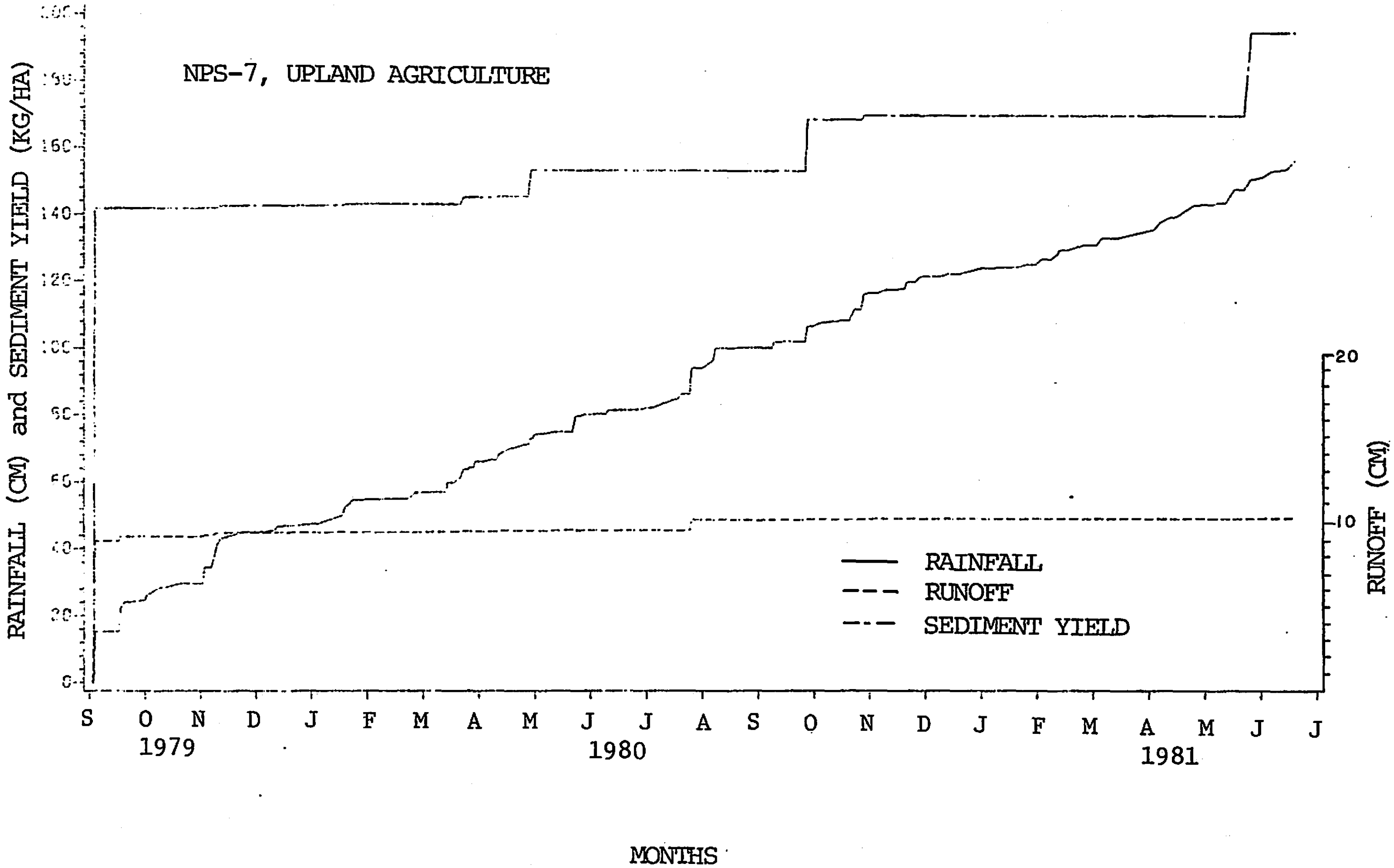


Figure 15. Cumulative rainfall (cm), and sediment yield (kg/ha) at the upland agriculture catchment, NPS-7.

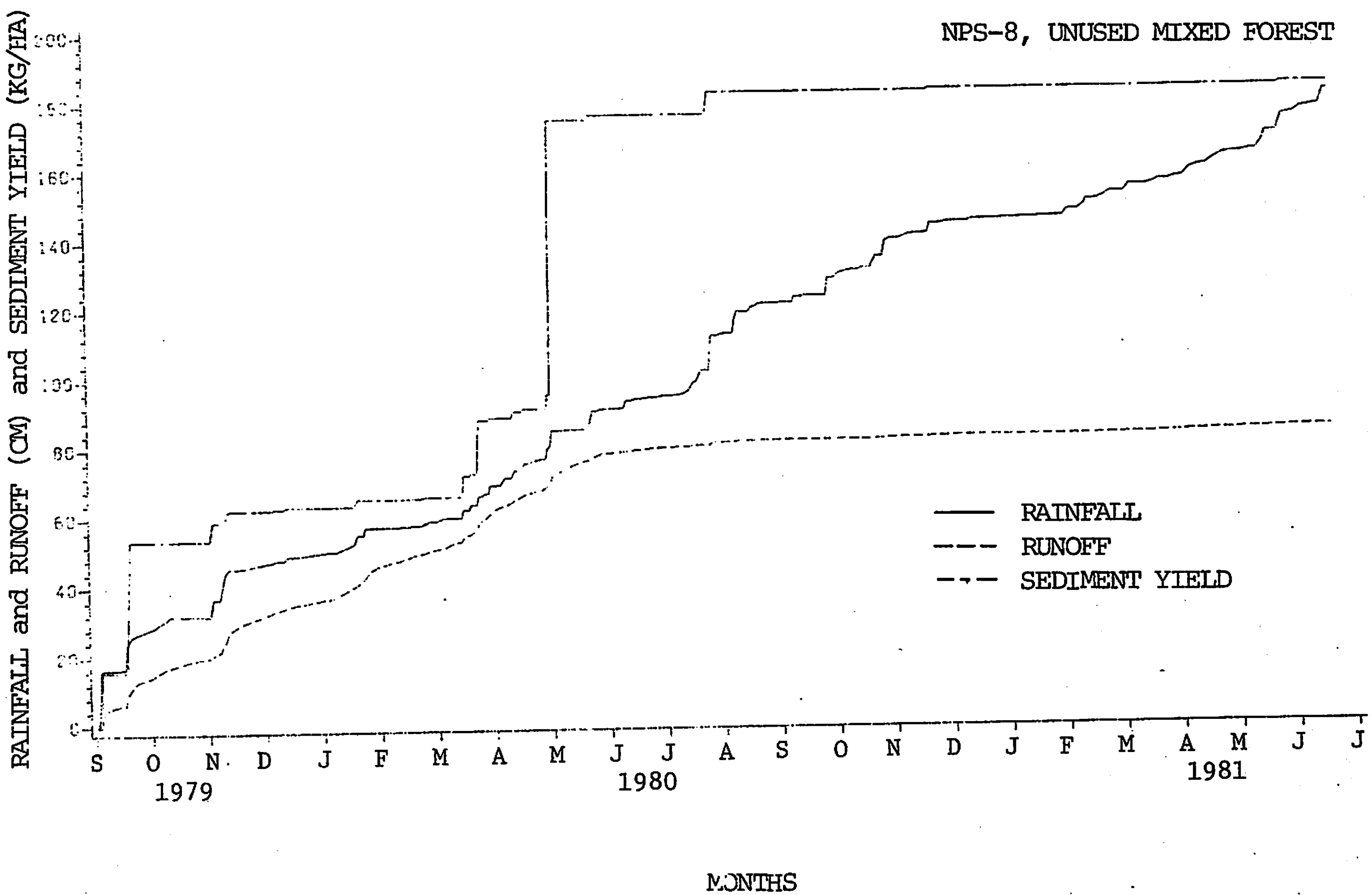


Figure 16. Cumulative rainfall (cm), and sediment yield (kg/ha) at the unused mixed forest catchment, NPS-8.

TABLE 5. Runoff (cm) at the Four NPS Sites Before and After the Drought

Site	Pre-June 1980	After June 1980	Total
NPS-2	10.14	0.22	10.36
NPS-5	67.24	2.33	69.57
NPS-7	14.21	1.18	15.39
NPS-8	77.68	5.73	83.41
% of Total	94.7%	5.3%	

Another important feature illustrated by the graphs are the varying magnitudes of individual runoff episodes. It is quite obvious that pollutant loadings are not evenly distributed among storms. Nearly 90% of the loading at the two agriculture sites occured during single storms early in the study period when conditions were wet and the catchments responded to rainfall with large runoff volumes. Conditions were also wet during the spring of 1980, and a series of rain episodes in rapid succession caused high individual event loadings from the forested and residential areas.

As a result of the patchiness of the runoff response at the catchments, no statistically significant relationships between runoff and pollutant loading were established. Correlations between the amount of runoff flow and rainfall were poor. Loading rates were equally patchy due to the lack of a rainfall/runoff relationship. The only apparent relationship indicated that loading rates are more a function of the runoff flow of a particular event rather than the concentration of the particular constituent. In other words, the amount of pollutants leaving the sub-basins were controlled by the amount of water leaving them. Thus, factors which affect runoff volume (ie. soil moisture, topography, rain intensity) appear likely to be the factors determining pollutant loading.

TABLE 6. Summary of Total Rainfall and Runoff (Baseflow and Stormflow) at the Four Catchments, September, 1979 - July, 1981.

	Lowland* Agriculture (NPS-2)	Residential (NPS-5)	Upland Agriculture (NPS-7)	Forest (NPS-8)
I. Rainfall (cm)				
Total	105.2	135.5	156.2	181.1
Rainfall which caused stormflow (% of total)	29.2 (27%)	100.0 (74%)	67.5 (43%)	124.4 (68%)
II. Runoff (cm)				
Total	10.4*	69.5	15.4	83.4
Stormflow (% of total)	8.5 (82%)	37.1 (53%)	15.4 (100%)	28.7 (34%)
Baseflow (% of total)	1.9 (18%)	32.4 (47%)	0	54.7 (66%)

*Does not include data from December 1979 - April 1980 when the monitoring station was inactive.

The forested site produced the greatest amount of total flow, while the greatest amount of stormflow was measured at the residential site (Table 6). Baseflow is defined as the residual flow recorded during nonstorm conditions, and is clearly an important component at NPS-5 and NPS- 8. The man-made ditches and impervious surfaces at the residential site were expected to accelerate surface runoff there. The well drained upland agriculture site yielded no baseflow and little surface runoff. Unfortunately, the five months of record absent for NPS-2 represent a period when storms were frequent and baseflow was high, and the results tabulated cannot be meaningfully compared with the longer records for the other three sites.

The upland agriculture site (NPS-7) had flows that were entirely ephemeral and were small in comparison to the other catchments. This is probably due to the fact that much of the rainwater is lost to percolation into the rapidly permeable soils. Only 43% of the precipitation monitored produced runoff. An interesting and somewhat anomalous feature is that runoff was greater during the summer than any other season at this location, while at the other sites, fall and winter produced the greatest amount of stormflow. This may be due to the fact that the types of storms during the summer are localized, short-lived, and intense. Should this intensity exceed the infiltration rate and persist, the result would be rapid runoff. A winter frontal storm, on the other hand, might deliver the same amount of rain, but over a much longer period and the soils would be able to assimilate a larger percentage of the total rain. Runoff coefficients (R) for the study sites were as follows:

Site no.	Average R	N
NPS-2 (lowland agriculture)	0.16	9
NPS-5 (residential)	0.35	49
NPS-7 (upland agriculture)	0.05	18
NPS-8 (forest)	0.27	38

Where R= Stormflow/Stormrain; and N= The number of events used to compute the average R.

The value for NPS-2 was established using the data available. In fact, all of the coefficients are based on somewhat incomplete data, since some storms were not monitored because of equipment failures. R values were highly variable atlthough mean values showed maximum runoff during winter, when soils were either saturated or frozen.

It was found that storms during the wet months were not only producing high values of R, but also yielding more water in the resultant flow than actually fell on the catchment (R>1.0). The high R values suggested that subsurface flow was entering from outside the surface drainage area during storms, through recharge from a larger subsurface drainage basin, or flux of water previously stored in the soil. The subsurface flow field was not monitored in this study, but R values of 1.2 and 1.4 at NPS-5 suggest that the groundwater basin includes a greater area than that defined by the surface contours. This indicates that subsurface flow should be monitored to adequately characterize these low-lying coastal areas and should be factored into the flow routing of the watershed models. The hydrologic response at the upland agriculture site (NPS-7) supports this. Although there was very little storm runoff because of the permeable soils, there was probably transport of water out of the catchment as subsurface flow. Until the groundwater transport is quantified, the pollutant potential of the catchment remains uncharacterized.

The impact that the seasonal water table can have on storm loads is illustrated by the hydrographs in Figure 17 and 18. The March storms had less intense rainfall yet produced much greater total flow. The hydrographs lasted at least one full day before the baseflow returned to the conditions prior to the storm. Unfortunately, the smaller runoff events during th summer were not sampled for water quality because not enough volume was collected for the analyses. The spring storms brought at least 10 times the flow per unit area than those in the summer at the forested and residential catchments.

UNUSED MIXED FOREST, NPS-8

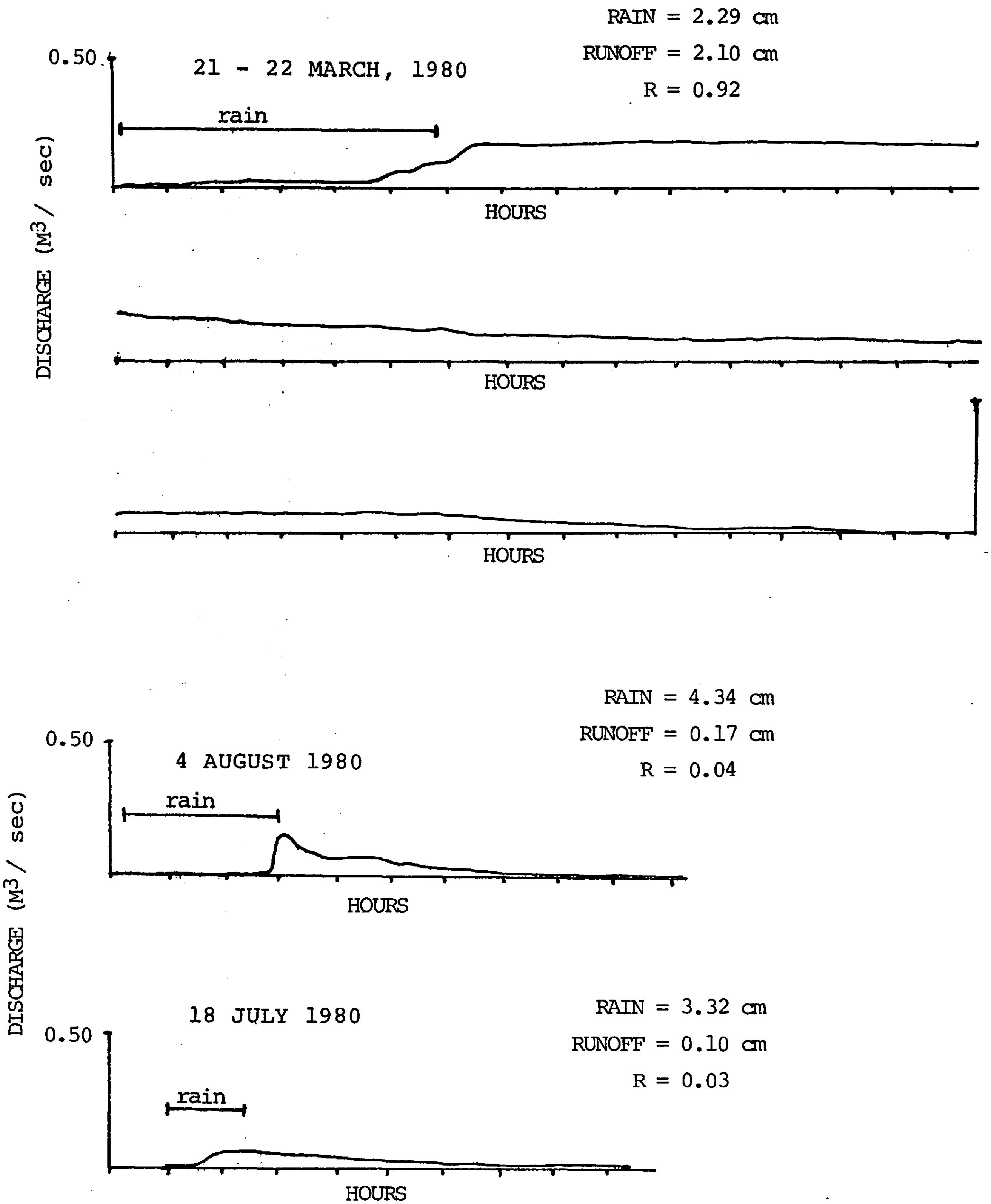
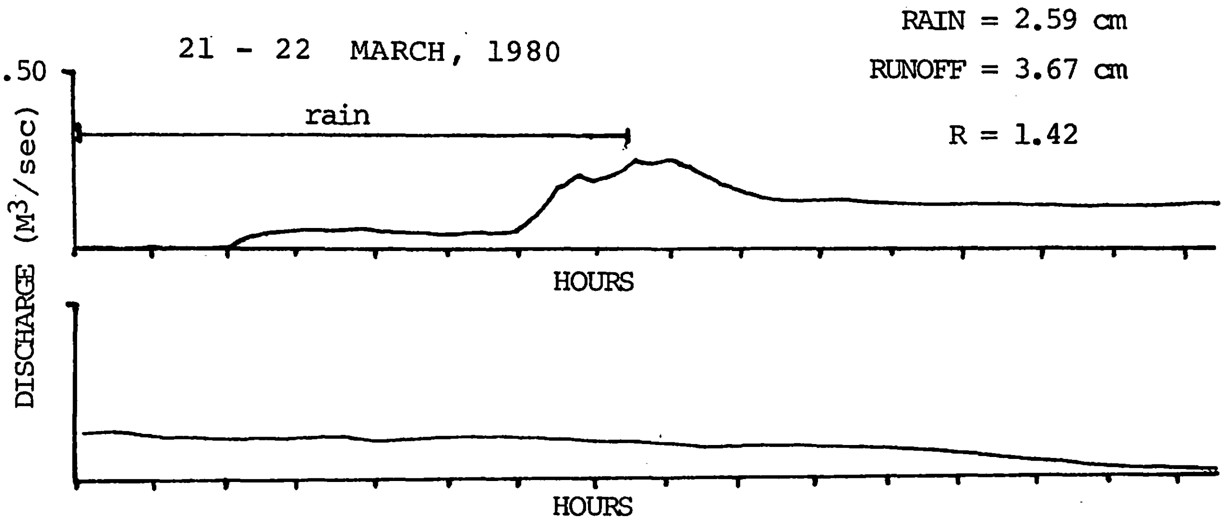
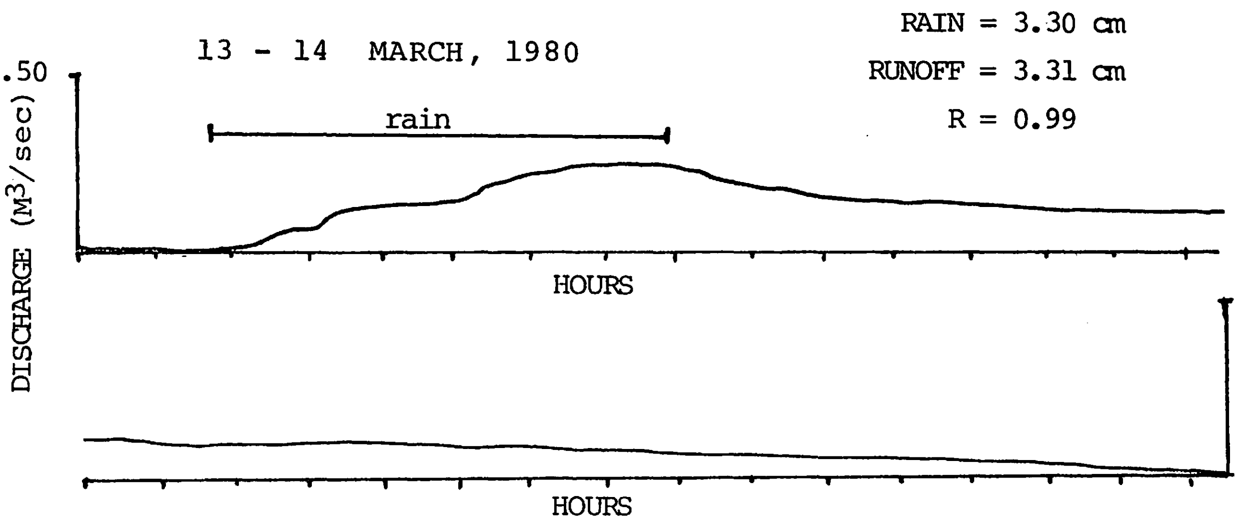


Figure 17. Sample hydrographs from the forested site, NPS-8, showing runoff yields during the spring and summer, 1980.

LOW DENSITY RESIDENTIAL, NPS-5





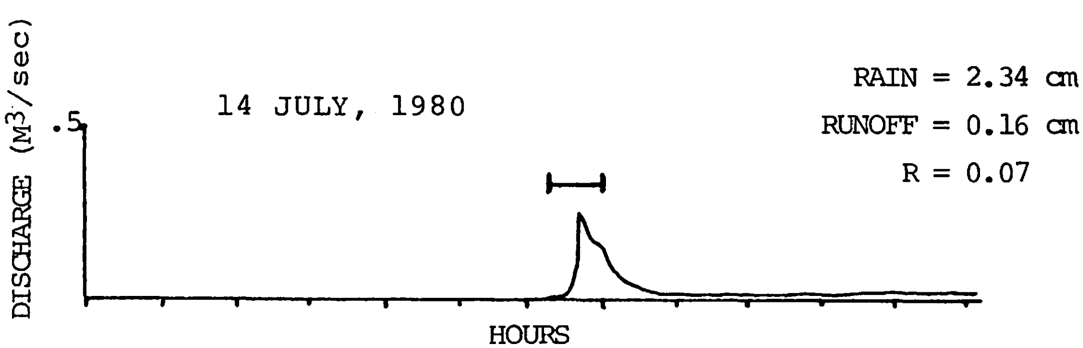


Figure 18. Sample hydrographs from the low density residential site, NPS-5, showing runoff yields from the spring and summer, 1980.

The monitored storms were placed into four classes, based on total precipitation, for the purpose of assessing the effect of storm size on the amount of runoff produced. The results are summarized in Table 7 below.

TABLE 7. Runoff (cm) vs Storm Size (cm)

	Runoff (cm)				
Storm Size	*NPS-2	NPS-5	NPS-7	NPS-8	Total
I	0.10	6.35	0.04	2.37	8.85
(0-1.25 cm)	n=2	n=21	n=4	n=8	n=35
II	0.73	6.80	0.1	6.39	14.03
(1.25-2.50 cm)	n=3	n=17	n=4	n=14	n=36
III	0.16	9.66	0.36	6.43	16.62
(2.50-5.00 cm)	n=2	n=7	n=7	n=14	n=30
IV	7.49	14.25	9.60	13.53	44.87
(+ 5-0 cm)	n=2	n=4	n=3	n=4	n=13

*Data from NPS-2 does not include the period from December 1979 through April 1980.

The most frequently monitored storm size, the 1.25-2.50 cm class produced only 10% of the total runoff. 73% was produced by storms greater than 2.50 cm (1.00"), which account for only about one-third of the number of events sampled. Better than one-half of the total runoff resulted from the thirteen storms which were larger than 5.00 cm (2.00").

RUNOFF QUALITY

The water quality characteristics of stormflow and baseflow are discussed in this section. Stormflow averages consist of the data from both grab and composite samples. Baseflow, or dryflow averages are calculated from those samples collected at the catchments at the time of slackwater sampling in the estuary. Baseflow samples were not collected during the summer months because the catchments were dry.

STORMFLOW vs BASEFLOW - Concentrations of all constituents were greater in stormflow than baseflow except for dissolved silica (Table 8). Increases in concentration were generally by a factor of two. Suspended solids levels, however, were substantially higher, by roughly an order of magnitude increase. The atomic ratio of total nitrogen to total phosphorus was greater in stormflow than in baseflow, demonstrating a greater increase in nitrogen relative to the increase in phosphorus during periods of runoff, even though runoff from the two cultivated fields was enriched with phosphorus. The NBOD5, (or difference between BOD5 and one inhibited for nitrifiers) was also greater in runoff, probably due to the increased amount of nitrogen available.

DIFFERENCES IN RUNOFF QUALITY AMONG SITES - The forested site might be considered a 'control' in relation to the remaining three sites which are, of course, impacted by man. Concentrations there during runoff were the lowest, and in many cases, below detection limits for the various species of nitrogen and phosphorus; TKN values were detectable, about 0.4 mg/l.

The residential site resembled the forested site in terms of runoff quality, except that inorganic species of phosphorus and nitrogen were higher here. The similarities in particulate constituents between the forested site and this catchment can be explained by the fact that housing here is sparse, preserving much of the natural ground cover. Much greater differences would have been expected had the residential catchment been more urban in character (more impervious cover). The elevated inorganic forms of nitrogen and

TABLE 8. Mean concentration of water quality constituents in baseflow and stormflow samples collected at the four catchments during the period April 1979 - August 1981.

Parameter	NPS-2 Lowland Agriculture	NPS-5 Residential	NPS-7 Upland Agriculture	NPS-8 Forest	
No. of Samples	15	9	0	23	Baseflow
	26	43	18	46	Stormflow
Total Phosphorous	0.08	0.04	-	0.03	Baseflow
	0.37	0.17	1.69	0.07	Stormflow
Total Nitrogen	0.47	0.35	-	0.13	Baseflow
	2.36	0.96	3.50	0.47	Stormflow
Orthophosphorous	0.04	0.01	-	0.01	Baseflow
	0.11	0.05	0.41	0.01	Stormflow
Ammonia Nitrogen	0.04	0.02	-	0.02	Baseflow
	0.24	0.05	0.11	0.02	Stormflow
Nitrite-Nitrate	0.09	0.18	-	0.01	Baseflow
Nitrogen	0.91	0.30	0.37	0.05	Stormflow
Suspended Solids	6.0	9.4	-	2.3	Baseflow
	104.5	51.4	706.4	41.3	Stormflow
BOD_5	1.12	1.12	-	0.86	Baseflow
	3.45	3.10	5.90	1.60	Stormflow
Dissolved Silica	2.81	5.66	-	3.13	Baseflow
	1.96	3.13	0.51	2.37	Stormflow
Total N:Total P	13.4	10.2	-	0.92	Baseflow
(Atomic)	21.35	15.8	9.48	15.98	Stormflow
TKN/TKNF	1.06	1.08	-	1.00	Baseflow
	1.93	1.93	3.24	1.63	Stormflow

phosphorus at the residential site could be the result of leaching from subsurface septic fields and fertilizer applications to gardens and lawns. Note also that the atomic ratio of nitrogen to phosphorus is quite a bit higher than at the forested site due to the higher concentrations of nitrite-nitrate.

The two agriculture sies had substantially higher concentrations of all constituents than the forested and residential sites. A particularly important feature is that concentrations of nitrogen forms are elevated near the time of planting and fertilizing application, particularly in the wet spring of 1979. Figures 19 and 20 show the seasonal changes in concentrations of TKN and the inorganic forms of nitrogen in runoff (nitrite, nitrate, and ammonia nitrogen). The one baseflow sample collected at the lowland sites (NPS-2) after fertilizing however did not show increases in concentration for any constituent. Unfortunately, no rain occurred between the time of application and when the baseflow sample was collected, so there would have been little or no leaching of the ionic and dissolved forms into the groundwater. There were very few storms after the summer of 1980, and no particular trends could be seen in the 1980 - 1981 planting season data. Phosphorus concentrations were consistently high, but unaffected by fertilizer applications (Figure 21 and 22), except at the upland site during the spring of 1980.

The trends indicate that the concentrations of nitrogen in runoff can vary in response to fertilizer applications, depending upon the coincidence of the timing between applications and rainfall events. In 1979, when there were several large storms within 3 - 4 weeks after applications, the concentrations were significantly elevated, but then tailed off. Phosphorus loadings could show similar variations, although the pattern for phosphorus is much less clearly defined since the concentrations of total phosphorus were generally elevated throughout the year at the agriculture sites. Some minor differences between winter and summer BOD values were also observed, but generally, there were no seasonal trends for the other water quality constituents.

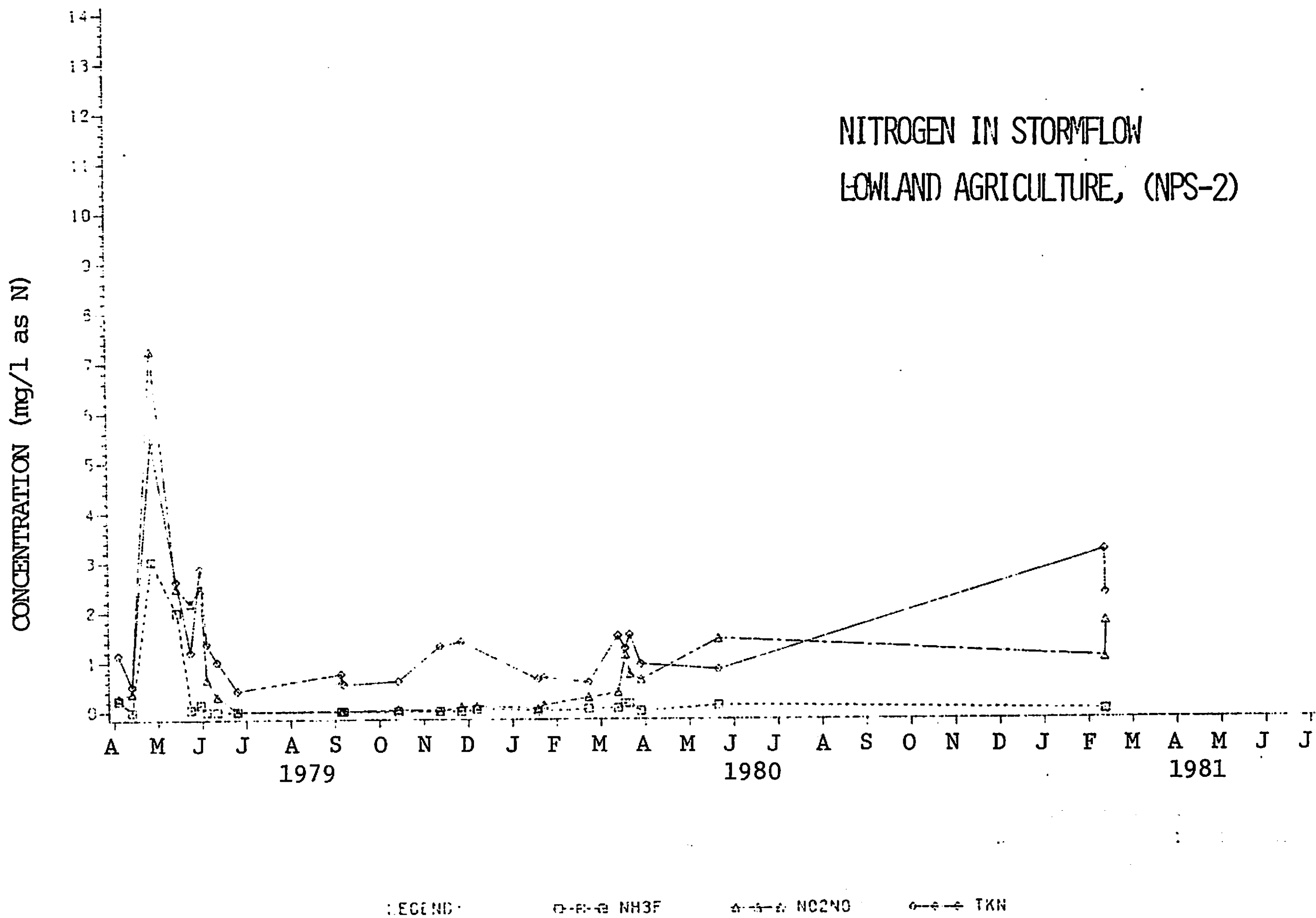


Figure 19. Concentration of Total Kjeldahl, Nitrite-nitrate, and Ammonia nitrogen (mg/l) at the lowland agriculture catchment, NPS-2, in stormflow samples collected during the study period.

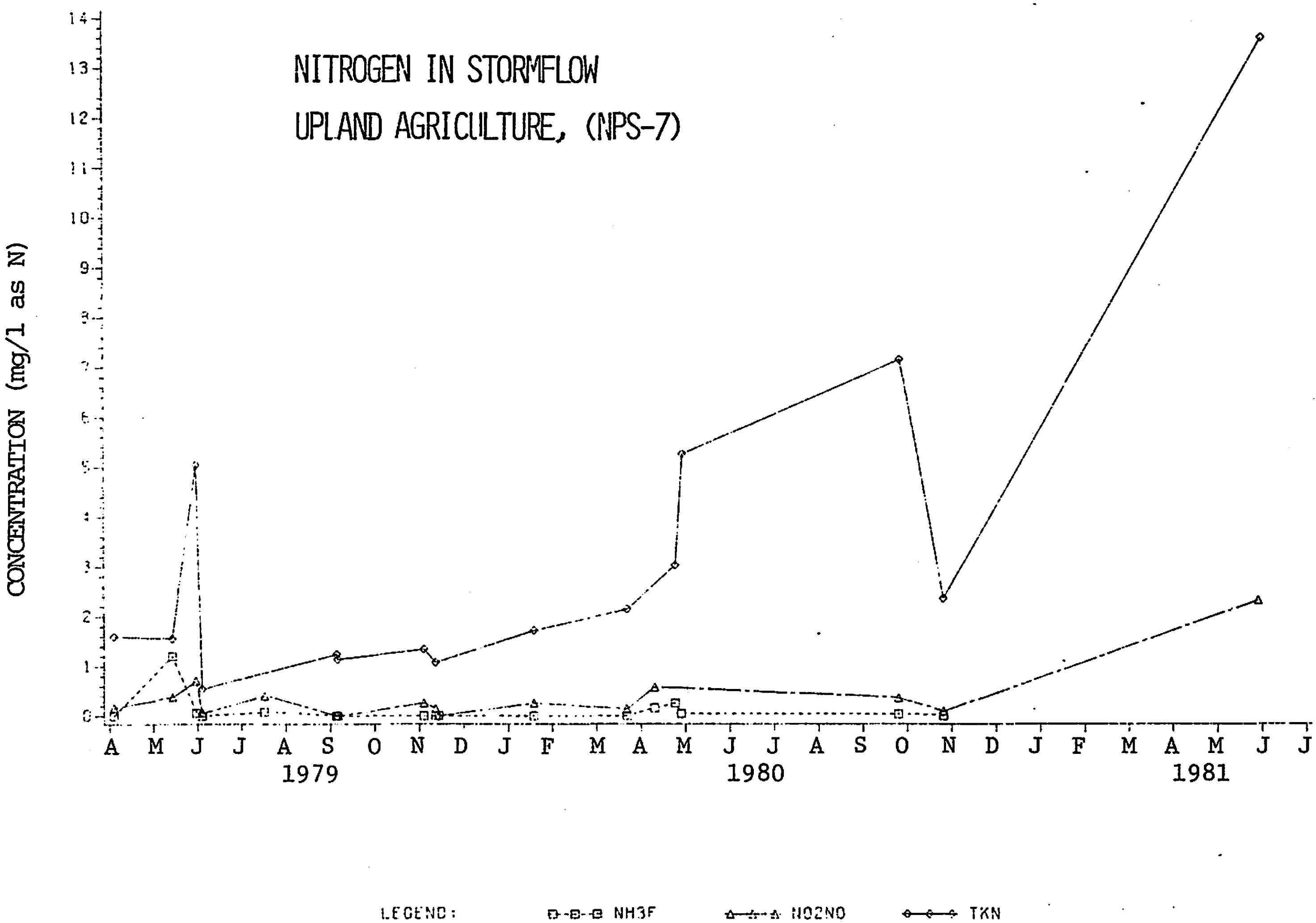


Figure 20. Concentration of Total Kjeldahl, Nitrite-nitrate, and Ammonia nitrogen (mg/1) at the upland agriculture catchment, NPS-7, in stormflow samples collected during the study period.

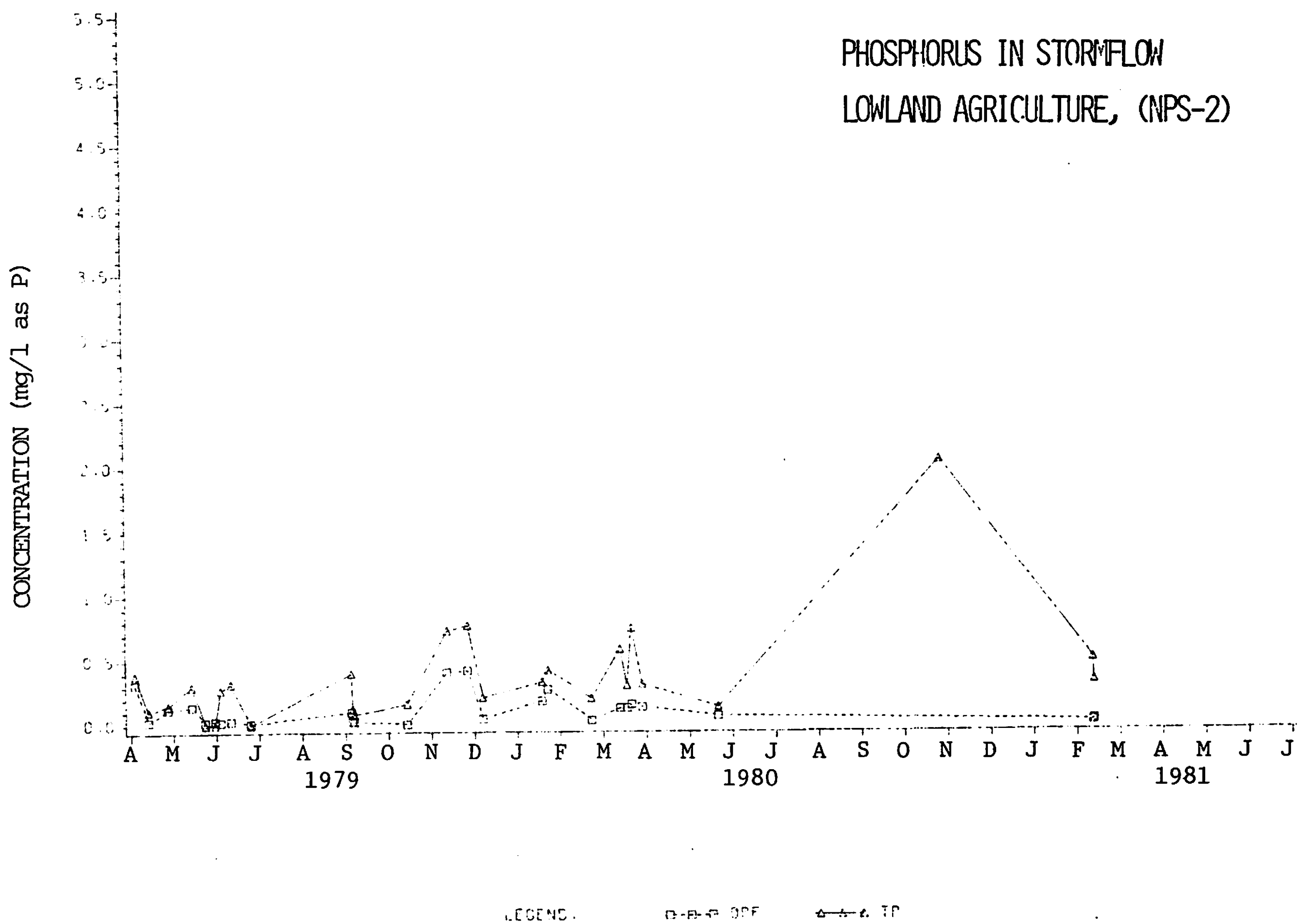


Figure 21. Concentration of Total Phoshporus and Dissolved Ortho-phosphorus (mg/1) at the lowland agriculture catchment, NPS-2, in stormflow samples collected during the study period.

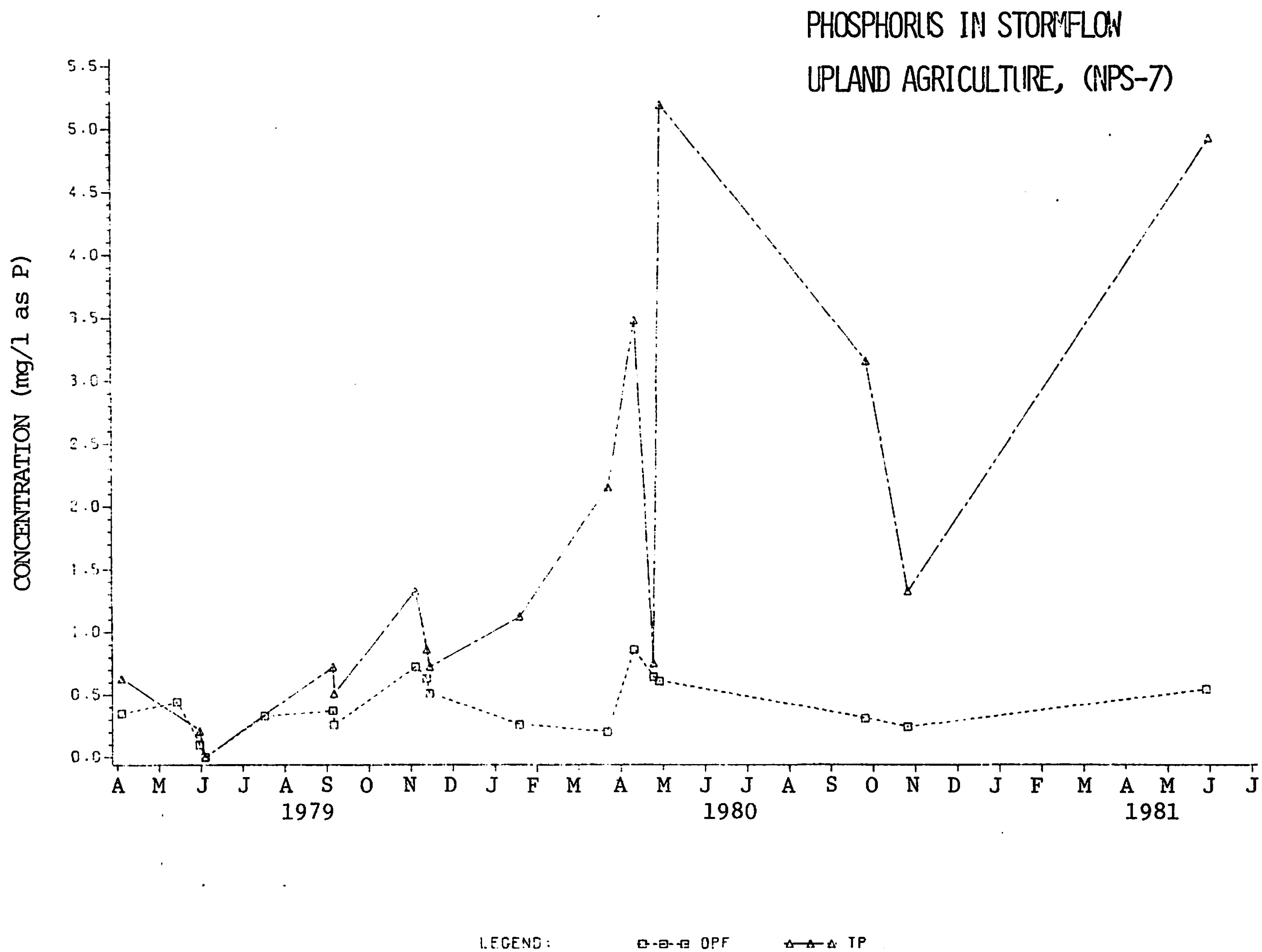


Figure 22. Concentration of Total Phosphorus and Dissolved Ortho-phosphorus (mg/1) at the upland agriculture site, NPS-7, in stormflow samples collected during the study period.

AREAL POLLUTANT LOADING RATES

It is useful for planning purposes to compare the pollutant potential of various land types and uses. As we have seen in the previous sections, rainfall-runoff relationships are complex, and pose a problem for the engineer who must make simple, meaningful interpretations for the user. The complexity of the data warrant the use of complex mathematical models which are intended to simulate the many processes which determine the pollutant yields in runoff.

In this section, the storm composite data are used to compare the loadings among sites. The runoff volume for each storm (in liters) is multiplied by the concentrations of the water quality constituents in the composite sample. These are then divided by the area of the particular catchment to yield a mass flux per unit area (hectares) value for each runoff event for each site. The data are treated and discussed in this section in two ways: 1) The individual event loads for each site are summed for all the events monitored during the 22-month period, and; 2) Each individual storm load is divided by the rainfall for that particular event to yield a mass pollutant per unit rainfall value for each storm. The usefulness of the latter is that the average storm loadings can be computed from the many storms monitored and expressed in units normalized to area and the amount of rainfall, so that sites having different areas and storm records can be compared. The calculated totals merely provide an absolute comparison among the sites, and suffer from incomplete records. Since rainfall-loading relationships were poor, no attempt was made to 'fill in' loadings for missed storms.

TOTAL POLLUTANT LOADING - Table 9 summarizes the pollutant loading from each site for the entire study period. The stormflow loads are the sum of the individual storm loads as described above, while the baseflow loads were calculated by multiplying the amount of baseflow which occured (Table 6) by the average concentration of the water quality constituents in baseflow (Table 8).

TABLE 9. Total Loadings for Baseflow, Stormflow and Total Flow

Parameter	NPS-2 Lowland Agriculture	NPS-5 Low Density Residential	NPS-7 Upland Agriculture	NPS-8 Forest	Baseflow Stormflow
Water (liters/ ha)	1.90×10^5	3.24×10^6	-	5.47×10^6	Baseflow
	9.50×10^5	3.71×10^6	9.88×10^5	2.87×10^6	Stormflow
	1.94×10^6	6.95×10^6	9.88×10^5	8.34×10^6	
Total Phosphorus (g/ha)	15.2	130	-	164.0	Baseflow
	614.3	422	560.2	203.5	Stormflow
	629.5	552	560.2	367.5	
Total Nitrogen (g/ha)	89.3	1134	-	711	Baseflow
	1157.6	2211	1158.1	1326	Stormflow
	1246.9	3345	1158.1	2047	
Orthophosphorus (g/ha)	7.6	32.4	-	54.7	Baseflow
	335.0	116.0	250.8	13.4	Stormflow
	342.6	148.4	250.8	68.1	
Dissolved Ammonia (g/ha)	7.6	64.8	-	109.0	Baseflow
	4.8	60.6	4.9	39.1	Stormflow
	12.4	135.4	4.9	148.1	
Nitrite-Nitrate (g/ha)	17.1	583	-	54.7	Baseflow
	38.5	1023.5	28.9	40.5	Stormflow
	53.6	1606.5	28.9	95.2	
Suspended Solids (kg/ha)	1.1	30.5	-	12.5	Baseflow
	139.6	108.2	194.8	183.3	Stormflow
	140.6	138.7	194.8	195.8	
BOD5 (kg/ha)	0.2	3.6	-	4.7	Baseflow
	5.2	5.2	6.9	3.3	Stormflow
	5.4	8.8	6.9	8.0	
Dissolved Silica (kg/ha)	0.5	18.3	-	17.1	Baseflow
	0.2	3.3	6.8	2.7	Stormflow
	0.7	21.6	6.8	19.8	

Although nutrient concentrations in runoff from both agriculture sites were significantly higher than at the other two sites, so little runoff occurred that the total loadings are lower than at either the forested or residential catchment. The reduced flow (an order of magnitude below the other sites) more than compensated for the higher pollutant concentrations in the runoff. An exception is phosphorus, however, which was highly enriched in runoff from the cultivated fields. Suspended solids were also very high coming from the denuded land. The highest total pollutant yields for these constituents were produced by the relatively few runoff episodes at the two agriculture sites.

The type of flow, as well as the amount of flow, is important too. The forested site and the lowland residential site had significant per area baseflow which were comparable in quality. The baseflow loading at these two sites were quite significant. Some of the similarity in water quality could be the result of the large number of trees on both occupied and vacant lots in the subdivision. Stormflow from the residential site, however, was greater than that from the forest on an areal basis. Since nutrient concentrations generally were higher in stormflow, the stormflow loading rates and therefore also the combined loading rates were higher for the residential catchment. Another notable feature of the residential catchment was the high loading of dissolved nutrients in baseflow, particularly orthophosphorus and nitrite-nitrate. This difference between the dissolved nutrient concentrations in baseflow of the residential and forested catchments may be due to leaching from nearby septic tank drainfields in the residential area.

Baseflow accounted for 35-60% of the total flow from the forested and residential sites. However, because nutrient levels were higher in storm runoff, roughly 70% of the total phosphorus, nitrogen and BOD5, and over 90% of the suspended solids loadings occurred during stormflow. If the upland agriculture site were considered as well, these values would increase since no baseflow was observed at the site during the study.

Dissolved silica is lower in runoff because it is absent in rainwater. The source of this nutrient is the weathering of mineral particles, particularly that caused by the groundwater flowing through soils. Therefore both loads and concentrations are higher during baseflow, although silica is still present during stormflows when surface runoff and silica rich groundwater are combined. As would be expected, the silica loading rate from the upland agriculture site was negligible since there was no groundwater contribution to the surface flow there.

If the two large storms which occurred at these sites early in the study period had been missed, say had the field program started in December of 1979, the total runoff (m3/ha) and suspended solids yields in Table 10 would have been reduced by 80%. This restates the need to acquire a long period of record to supply statistically meaningful loading data. The storm which produced the large runoff event at NPS-7 was residual rainfall from Hurricane David travelling up the east coast early in September 1979. Fifteen centimeters fell during about five hours, a storm which is expected to recur in the Tidewater Region only once each hundred years (Chow, 1964). This storm wasn't monitored at NPS-2, however, due to equipment failure. The storm which produced the high yield at NPS-2 only produced moderate flows at NPS-7, the well drained site. Very large runoff events were observed during the wet spring of 1979 at the two agriculture sites, prior to the installation of flumes. These were similar in magnitude to the runoff from David, but events of this size were not witnessed again during 1980 or 1981.

AREAL LOADING RATES - Loading rates have been calculated for individual storms which account not only for the catchment size but also the amount of rainfall. These loading rates, in terms of mass per unit area per unit rainfall, are shown in Figures 23-27. In this manner, comparisons can be made which utilize the few storms sampled at the two agriculture sites.

The results yield a different interpretation than those of Table 9, however. Although the two agriculture sites did result in the highest individual storm loading rate, the mean and median rates were greatest for the storms at the residential catchment. This is to say that most of the time the loading rate is highest at the residential catchment, and that occasionally a very high rate occurs at the other sites. Occasional high rates are important, and were responsible for most of the total load at the two agriculture sites. The ranges for all of the sites overlapped considerably,

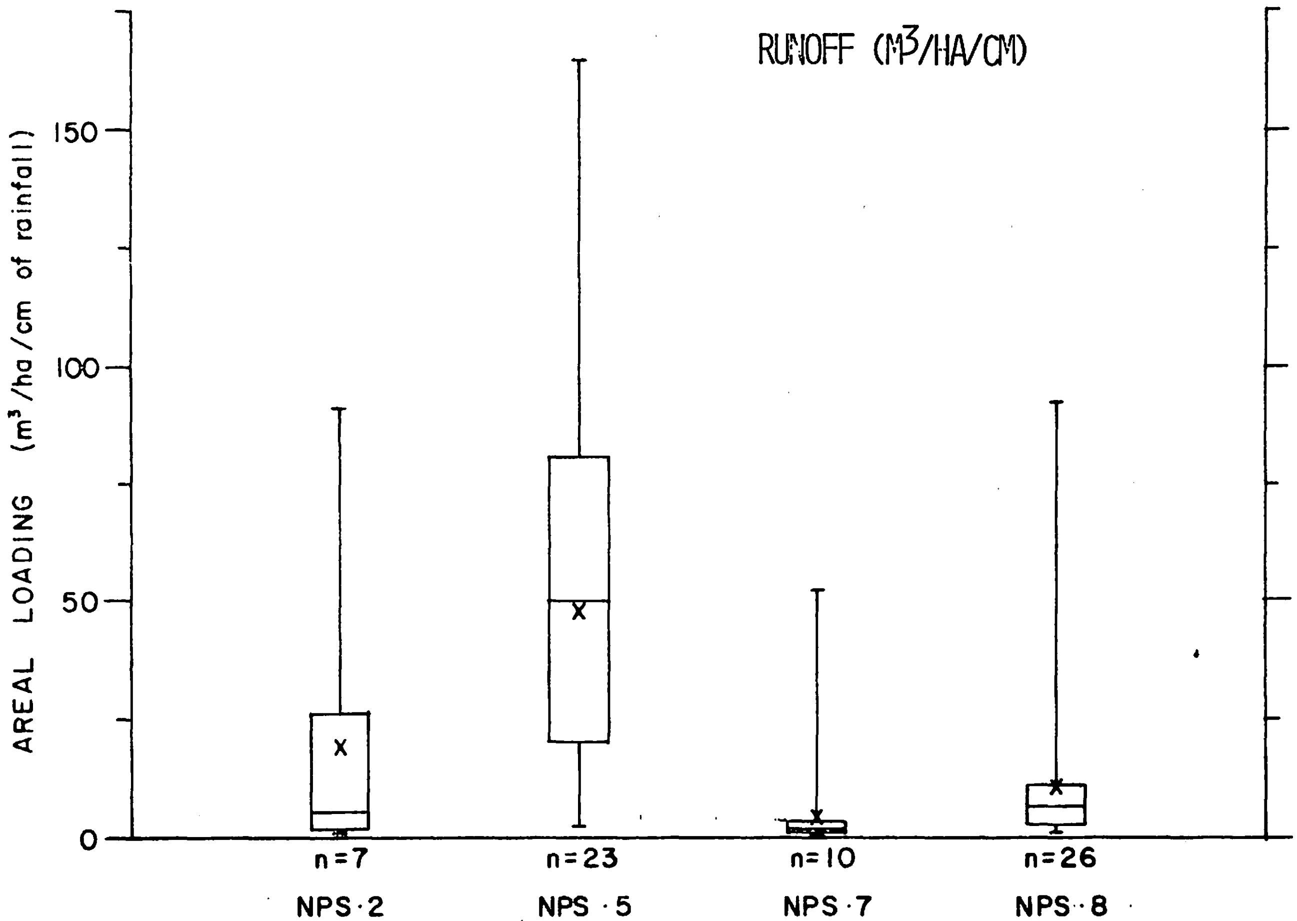


Figure 23. Areal yield of runoff (m^3/ha/cm of rainfall), Mean (X), range, and median statistics for the storms (N) monitored at each catchment.

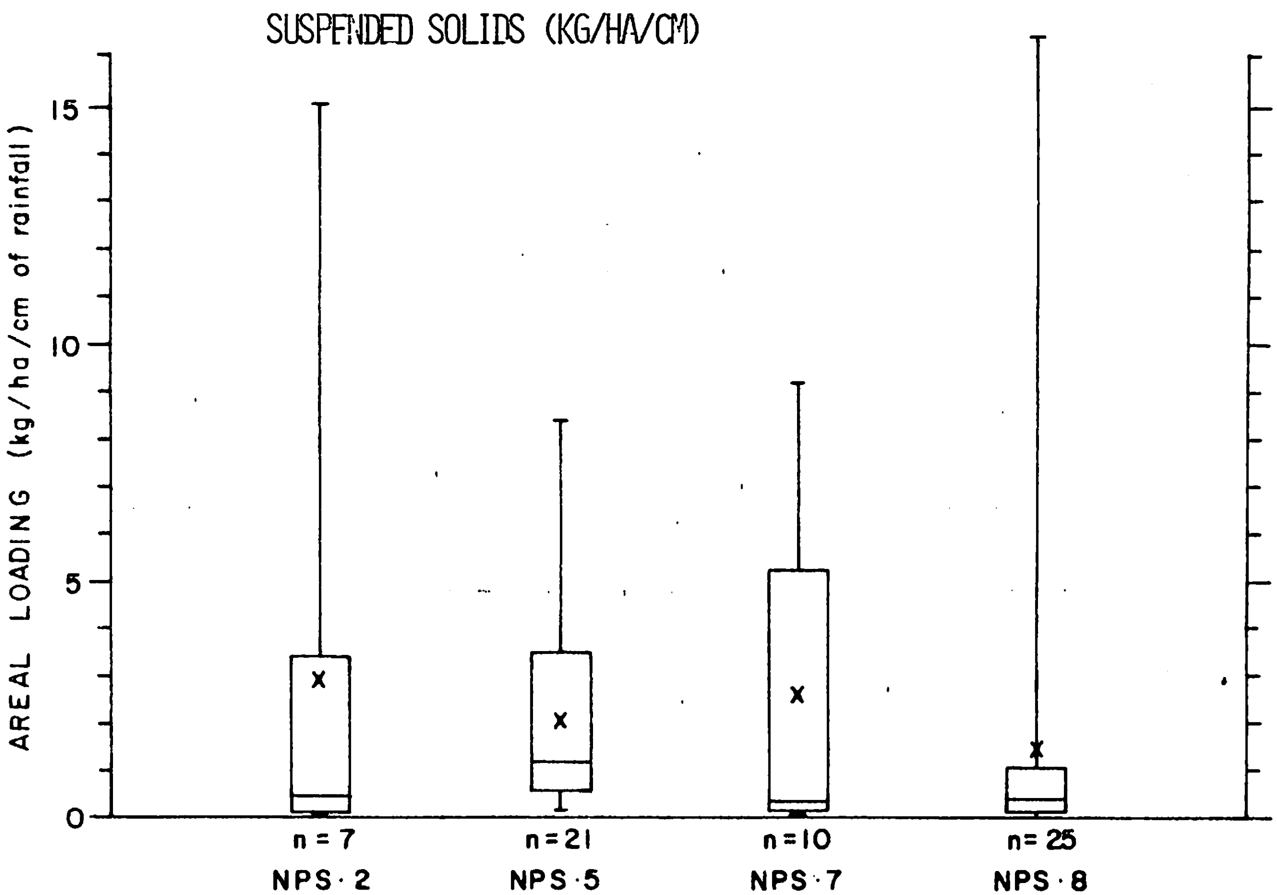


Figure 24. Areal yield of suspended sediment (kg/ha/cm of rainfall), mean (X), range and median statistics for the storms (N) monitored at each catchment.

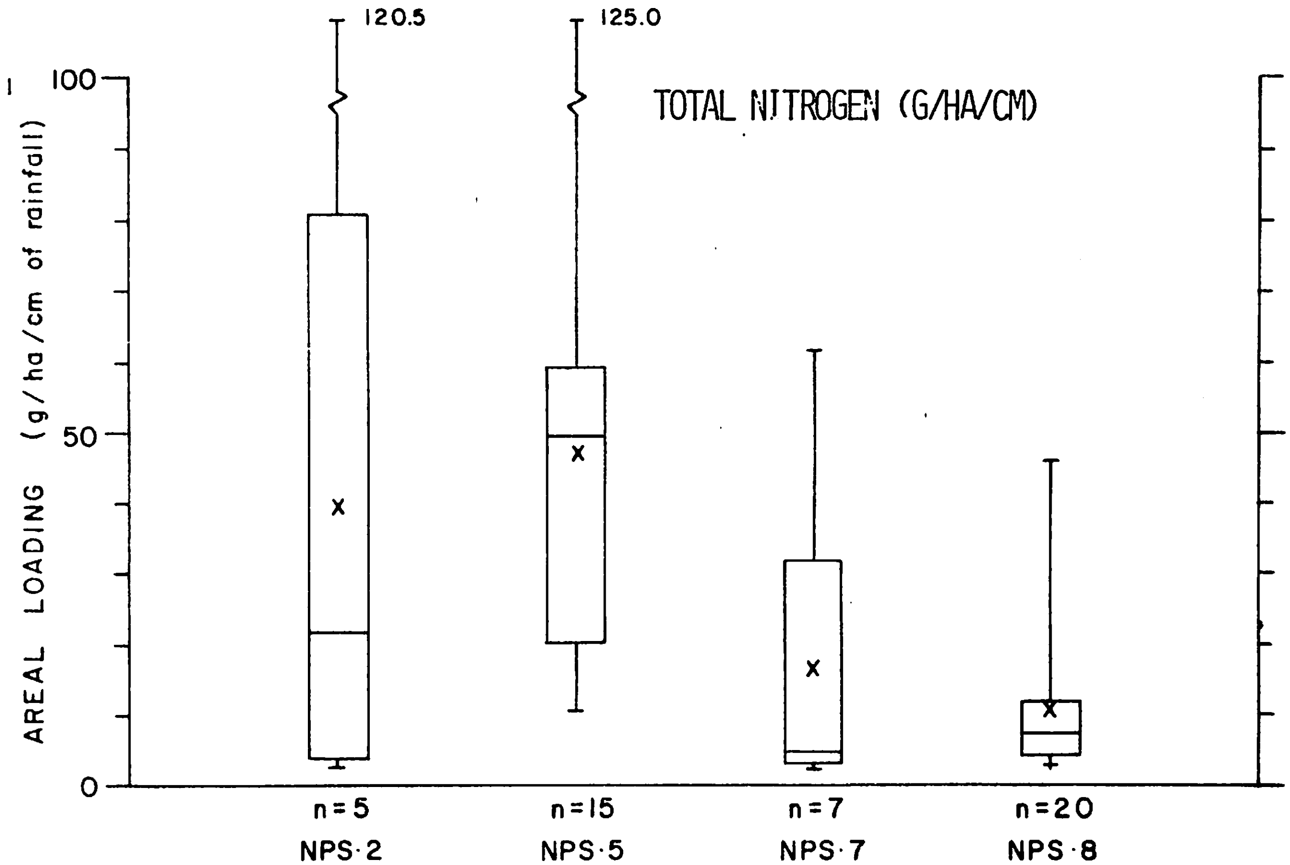


Figure 25. Areal yield of total nitrogen (g/ha/cm of rainfall), mean (X), range and median statistics for the storms (N) monitored at each catchment.

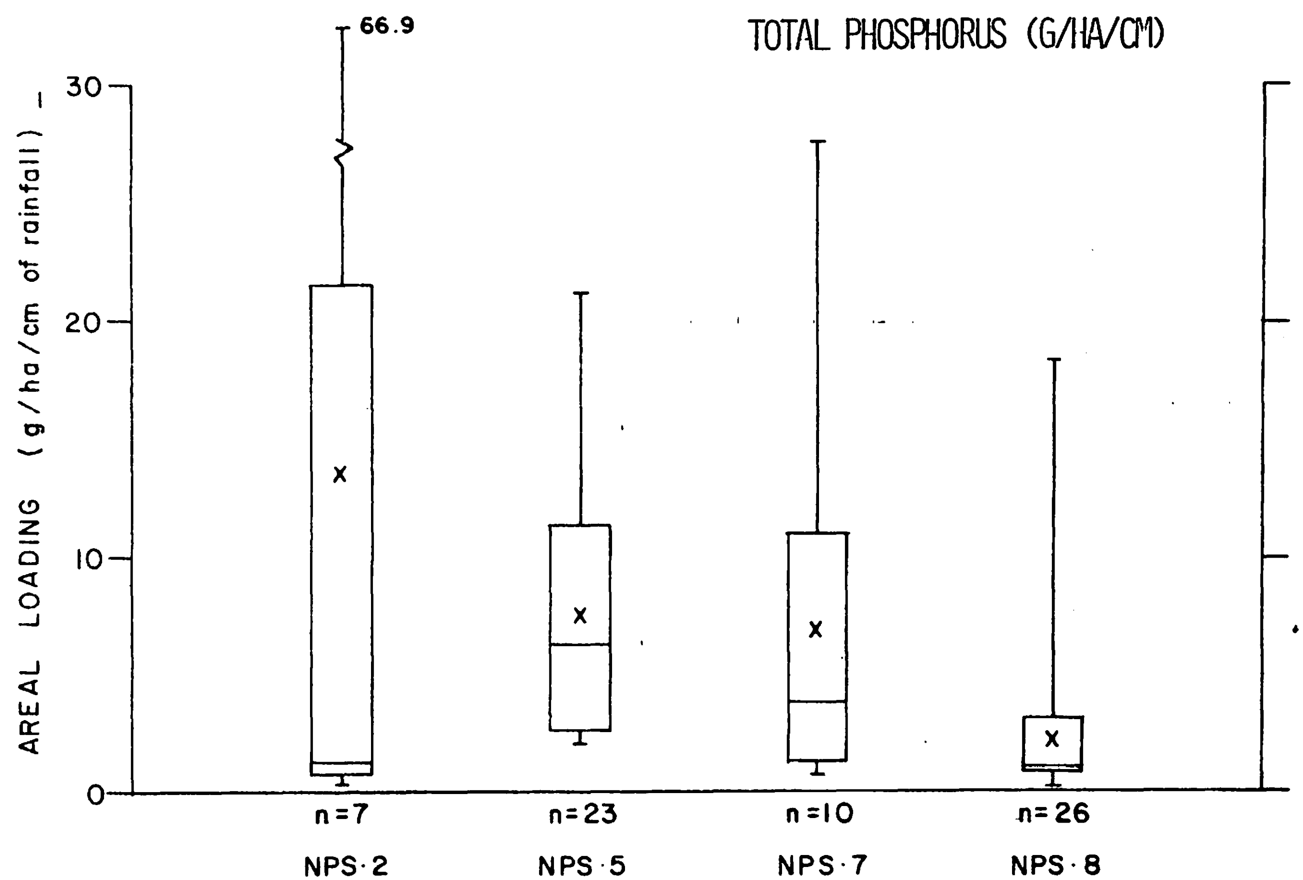


Figure 26. Areal yield of total phosphorous (g/ha/cm of rainfall), mean (X), range and median statistics for the storms (N) monitored at each catchment.

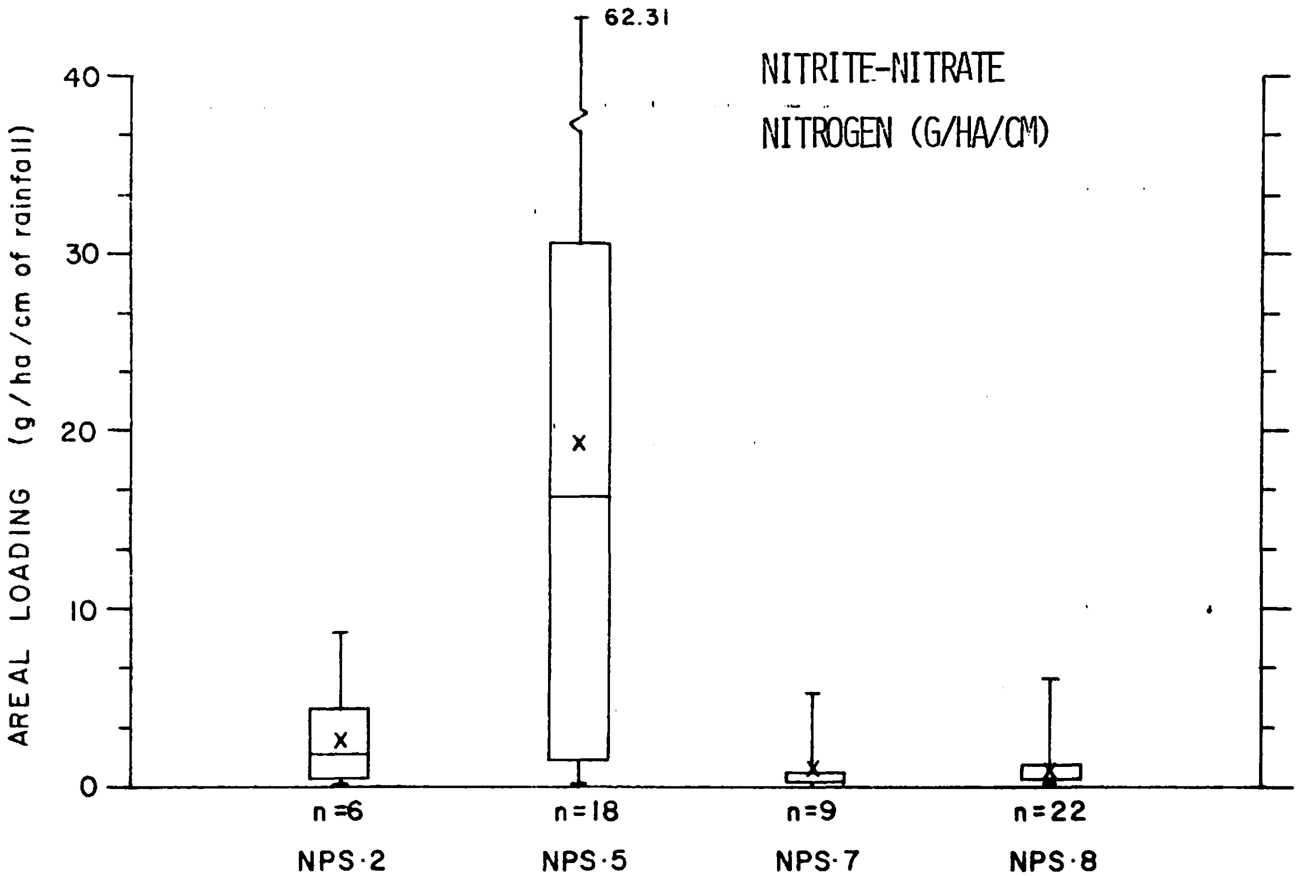


Figure 27. Areal yield of nitrite-nitrate nitrogen (g/ha/cm of rainfall), mean (X), range and median statistics for the storms (N) monitored at each catchment.

so that differences in these values are not statistically significant. Analysis of individual storms did not show any relationship between amount of rainfall and runoff or loading. Because loading rates are dependent on runoff volume, factors which determine the runoff coefficient (such as groundwater conditions and ground cover) are important factors affecting areal stormwater loading.

SECTION 6

SUMMARY

The primary objective of the Ware River Study was to gather data for use in nonpoint source model studies. From that point of view the project has been successful. The data have been used by others in the development of a nonpoint source model of the Chesapeake Bay basin, and the model has been used to project nonpoint source loads to the Bay.

The data from this study are of limited usefulness however, for making comparisons of catchments based on land use, since only three different uses were monitored. The observations from the Ware catchments followed expected patterns, but illustrate the importance of other hydrological factors in addition to land use which influence pollutant loading rates. The data from the two agricultural sites, for example, show how certain types of topography affect basin response to rainfall. The Ware study provides much needed information on the nature of hydrologic processes which are unique to the coastal physiographic province. These data and comparable studies conducted in the Maryland Coastal Zone (Chester River and Patuxent River) have begun to establish a data base which can be compared to the much more abundant runoff data available from other physiographic regions.

The results of the Ware Study also illustrate a number of points which are important to both data users and persons planning future runoff monitoring studies, namely:

1. Precipitation conditions can be highly variable from year to year, illustrating the need to obtain long term records which characterize extreme, as well as average rainfall conditions. This is especially true for catchments having little or no impervious cover, since runoff producing storms are infrequent at these sites.

2. For a given catchment, the loading rates calculated for individual storms are highly variable as a result of changes in rainfall characteristics, ground cover, soil moisture content, and other time varying factors.

3. Projections based on land use are best made by mathematical models which include these time varying processes as well as the physical properties that influence catchment hydrology.

4. Pollutant transport from coastal areas having a shallow water table can be increased due to groundwater contributions to surface runoff as well as subsurface transport of pollutants to nearby streams. Studies are needed which include groundwater investigations, and model algorithims need to be developed which account for the complicated processes that transport pollutants below the land surface.

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APPENDIX A

CATCHMENT DESCRIPTIONS AND SOIL DATA FOR SINGLE LAND USE STUDY SITES

TABLES

TABLE A1. Station ID: NPS-2 Lowland Agriculture

Location:	Gloucester County, Virginia; 0.93 kilometers Northwest of Zanoni, Virginia; Ware River Basin. 37°24'40"N 76°29'40"W
Area:	24.05 hectares.
Shape:	Roughly rectangular; 300 x 800 meters.
Slope:	100 percent is in 0-2% class. Aspect undefined in lower areas.
Soils:	Residual; heavy, loam texture, poorly drained; premeability slow. Meggett 42 percent, Lumbee 20 percent, Suffolk fine sandy loam 14 percent, Kempsville fine sandy loam 13 percent, Pactolus loamy sand 11 percent.
Erosion:	Slight, 100 percent.
Surface drainage:	Moderate, length of principal waterway 780 meters, a man-made watershed with parallel ditches draining crop fields to one main channel which flows 520 meters directly into the Ware River on south bank between Perrin and Hall Points.
Character of Flow:	Intermittent, groundwater fed, interrupted.
Instrumentation:	2.5 foot H-flume, continuous recording flowmeter, automatic composite water sampler, recording-precipitation gage, dual pen stripchart recorder (flow and precipitation), auxilliary recording raingage.
Watershed Conditions:	82 percent in row crop, 1979 planted in corn; 1980 split crops 55% corn and 27% soybean; 1981 55% soybeans and 27% corn. Conventional till, fertilizers, pesticides applied. Remaining 18 percent is wooded or fallow ground.
General Description:	Soils are very common to coastal plain eastward of "Suffolk Scarp". Approximately 4800 hectares of this type in Gloucester County. Common to Maryland, Virginia's Eastern Shore, and North Carolina.

TABLE A2. Station ID: NPS-5 Low Density Residential

Location:	Gloucester County, Virginia; 2.50 kilometers West of Ware Neck, Virginia; Ware River. 37°24'30"N 76°29'10"W
Area:	2.56 hectares
Shape:	Irregular; bounded by roads.
Slope:	100 percent in 0-2% class. Aspect undefined.
Surface Drainage:	Good, by roadside ditches, roughly 550 meters of interconnected ditches to one channel at a point 110 meters from Ware River. Drainage boundaries man-made and natural.
Character of Flow:	Intermittent groundwater fed, interrupted.
Instrumentation:	1.0 foot H-flume, recording flowmeter, automatic composite water sampler, recording precipitation gage, dual pen strip-chart recorder (flow and precipitation).
Watershed Conditions:	45 percent single family residential, 15 percent small row-crop or open space, 30 percent wooded, 7 percent hard surface roads.
General Description:	Roadways are asphalt, residences septic served. Single family lots are along bank of the Ware River or on interconnecting roadways within 460 meters of shoreline.

TABLE A3. Station ID: NPS-7 Upland Agriculture

Location:	Gloucester County, Virginia; 4.25 kilometers North-Northeast of Ark, Virginia; Beaverdam Swamp, Ware River Basin. $37^{o}27'52''$N $76^{o}33'25''$W
Area:	6.43 hectares
Shape:	Roughly rectangular; base 215 meters, height 300 meters.
Slope:	Approximately 90 percent in 2-6% class, 10 percent in 0-2% class. Aspect South-Southeast.
Soils:	Residual; topsoil sandy loam texture 25-50 cm deep, well drained; subsoil sandy clay loam to sandy loam texture, 75-100 cm deep, permeability moderately rapid to rapid. Kempsville Sandy Loam 35 percent, Suffolk fine sandy loam 10 percent, Psamments-Hapludults complex 32 percent, Ochlokonee-Ochlokonee variant 20 percent.
Erosion:	Moderate, 80 percent; Severe, 20 percent.
Surface Drainage:	Very good; three interconnected sod waterways of approximately 140 meters length combine to form one main waterway; bounded by roads on three sides, natural boundry on fourth side.
Character of Flow:	Ephemeral, continuous.
Instrumentation:	2.5 foot H-flume, continuous recording flowmeter, automated composite water sampler, recording precipitation gage, dual pen stripchart recorder (flow and precipitation), auxilliary recording raingage.
Watershed conditions:	10% in sodded waterways, 80% in row-crop, and 10% wooded. 1979 planted in corn, 1980 crop is soybeans. Conventional till, fertilizers, pesticides and lime applied. 1981 planted in corn using no-till planting technique.
General Description:	Soils are a mixture of types commonly found in co-occurance in coastal plains of Southern Maryland, Virginia and North Carolina. Approximately 3650 hectares of this type in Gloucester County.

TABLE A4. Station ID: NPS-8 Mixed Unused Forest

Location:	Gloucester County, Virginia; 0.40 kilometers North, Northeast of Ark, Virginia; Beaverdam Swamp, Ware River Basin. 37°26'50"N 76°35'30"W
Area;	7.22 hectares.
Shape:	Roughly fan shaped, radium 370 meters, length of 600 meters.
Slope:	80 percent in 2-6% class, 20 percent in 6-12% class. Aspect South-Southeast.
Surface Drainage:	Good, length of waterway 60 meters fed by two branches of 240 and 180 meters respectively, total length of waterway 300 meters, natural boundry.
Character of Flow:	Spring fed intermittent, continuous.
Instrumentation:	1.0 foot H-flume continuous recording flowmeter, automated composite water sampler, recording precipitation gage, dual pen stripchart recorder.
Watershed Conditions:	95 percent is undisturbed mixed forest, 5 percent is unused open space.
General Description:	This sub-basin is essentially free of disturbances due to man and beavers. It is part of a larger watershed which has been impacted greatly by beavers, but only slightly by man.

TABLE A5. The Area of Soil Units at Each NPS Site.

Site No.	SCS Series Name	Area (Ha.)
NPS2, Lowland Agriculture	29B Suffolk, fine sandy loam	0.45
	29C Suffolk, fsl	2.96
	13B Kempsville, fsl	3.19
	24B Pactolus, loamy sand	2.48
	18 Meggett, sandy loam	10.13
	16 Lumbee, sl	4.83
NPS5, Low Density Residential	1B Alaga, loamy sand	0.13
	6 Eunola, fsl	2.04
	12B Kalmia, sl	0.38
NPS7, Upland Agriculture	13B Kempsville, fsl	2.27
	19 Ochlockonee-Ochlockonee	1.17
	27C Psamments-Hapludults	2.06
	28B Rumflord, fsl	0.32
	29B Suffolk, fsl	0.61
NPS8, Unused Mixed Forest	5B Emporia, fsl	2.25
	31A Wrightsboro variant	1.78
	31B Wrightsboro variant	0.39
	9D Hapludults variant	2.78

APPENDIX B

RUNOFF MONITORING PROCEDURES, SITE VISITATION CHECKLIST, INSTRUMENT MAINTENANCE SCHEDULES

TABLES

Table B1. Runoff Monitoring Procedures: April 1979 - August 1980

Phase I: April - August 1979

During phase I, grab samples were collected during the more significant storms (>0.50") and runoff flows were observed for future sizing of the H-flumes. Since stormflows were not quantified, loading rates could not be projected for this time period. Recording raingages installed at NPS-2 and NPS-7 provide coverage of the watershed since the beginning of slack-water monitoring in April 1979.

Phase II: September 1979 - January 1980

In September 1979, when flowmeters and composite samplers were installed, monitoring of runoff volumes and mass flux of constituents began. The rain-gages for each site could not be installed as they would not work without the recorders which had not been received. The precipitation data for this period was still provided by the auxilliary gages at NPS-2 and NPS-7.

Sites were visited once a week for battery changes and maintenance, and before and after storms to turn the composite samplers on and off. At the time of site visits, total flow (ft^3) and water height (ft) in the flume was recorded in a log book along with date, time, and notes on watershed conditions.

In order for total event flow to be successfully monitored, a site had to be visited within 12 hours prior to a storm and no later than 12 hours following. Thus, storms were not monitored on occasion because they were missed or not forcasted. In order for the composite samplers to work properly the flowmeter had to also be working, sending a signal to the sampler initiating the pumping cycle. Thus, there are no composites collec-ted when the flow record is incomplete. This sampling and flow monitoring procedure was also employed during phase III, except that stripchart records provide a trace of the runoff hydrograph during all storms, whether success-fully sampled or not.

Although flumes, flowmeters, and samplers were in place at all four sites, runoff monitoring during September, 1979 was highly incomplete due to im-proper instruments, flooding, and changing the location of one of the flumes late in the month. The flowmeters to be used at the two agriculture sites were sent with the improper stage-discharge relationship, and therefore inaccurate flow readings were recorded until the proper instruments arrived on 8 September. This was particularly important since runoff from the large rains brought Hurricane David on 5-6 September were inaccurately gaged, an event which probably brought as much as 50% of the total runoff for the remaining months of 1979. Hurricane David brought other unanticipated problems. The flumes at both the forested and residential sites were flooded by the storm, causing the runoff record at these sites to also be incomplete. Not only was the flume at the lowland agriculture site submerged, the corn fields were under about a half meter of water as well. A 24-inch culvert downstream of the flume had collapsed, backing up water at least 1500 ft. into the catchment. This proved to be a problem during subsequent storms events as runoff monitoring could not be accomplished when the H-flume was greatly submerged. Late in the month (27 September), the flume at the residential site was moved upstream at the request of the project officer so that a greater percentage of impervious cover would be monitored, and to avoid the effect of a small pond (<0.05 ha) which impounded the runoff just upstream of the original flume site. Thus, the first month with complete data was October 1979. Although data from September are included in the SAS files transferred to EPA via magnetic tape, the data reported in the results section of this report begin with October and are continuous up to and including August 1980.

Phase III: <u>February 1980 - Present</u>

The stripchart recorders and raingages were installed in February 1980, thus completing the instrumentation of the monitoring sites. The recorders provide a continuous trace of runoff flows, even in instances when storms were not sampled because of inaccurate weather forcasting. The total flow data recorded during site visits can be used to verify the continuous records on the charts.

With installation of the recorders and raingages, the battery service interval increased to twice per week. Accumulated rainfall since the last site visit was recorded from the decade counter and tube raingage in addition to the total flow and water height data recorded during phase II. Flowmeters were calibrated during each visit, and raingages once per month. Table B-2 is a list of the procedures which are carried out during every site visit, Table B-3 is the maintenance schedule for servicing all equipment including the runoff catchments as well as climatological instruments at the weather station.

Table B2. Ware River NPS Site Visitation Procedures

1. Read rainfall from decade counter and tube rain gage, dump tube and reset counter, record in log book.

2. Read total flow and water height from flowmeter, set flowmeter dial on zero ft., record total flow in log book, record water height as H_I in log book.

3. Check amount of recorder chart paper remaining on spool, replace if necessary. Check time on chart, adjust if necessary.

4. Allow stripchart to trace for 3-5 minutes at zero height level, meanwhile. . .

    a) Turn sampler quickly from "auto" to "reverse", then to "forward", ending at "off" position, stopping at each just long enough to hear that pump is functioning properly. (Watch water in hose to see that it moves but does not contaminate sampler bottle.)

    b) Change battery.

    c) Turn sampler to "auto" if it is to run, change or pickup bottle if necessary.

    d) Log on/off in notebook; if sample picked up, place an asterisk next to the date.

    e) Sweep out flume and/or clean debris from sampler head, flume throat.

5. Adjust recorder pen to zero by turning screw on face of recorder.

6. Check water height in flume with staff gage.

7. Set correct water level on flowmeter dial (noting time), record correct water height as H_A in log book.

8. Check totalizer on flowmeter to see if total flow has changed due to battery change; if so, note. Check decade counter for same, re-reset if necessary.

9. Record time, date, total flow, sampler status, and rainfall on stripchart, using time when correct water level was set.

TABLE B3. WARE NPS MAINTENANCE SCHEDULE

FREQUENCY	ACTIVITY	EQUIPMENT REQUIRED
Before Anticipated Rain Event	Turn on all samplers. If necessary	Clean Bottles, if necessary; batteries
After Event	Pick up samples	Clean Bottles; batteries Field sheet; D.O. kit with thermometer; clean wetfall bucket
Every slack (Approx. monthly)	Grab sampling at Stream sites and all Flowing NPS sites	Sample bottles; Field sheet Dryfall Bucket; sampling Bucket with line; D.O. kit with thermometer
Every 3-4 Days	Change Batteries; Check Chart paper supply in Recorders	Batteries, chart paper
Weekly (approx. at beginning of each week)	Observe ground cover change charts -level recorders -white raingages -Roaring Springs raingage -Roaring Springs Hydrothermograph Wind clock & Dump bucket at Roaring Springs Read Anemometer Read Pan Evaporator	1 Hygrotherm chart 3 rain charts 2 stream charts Tape lg. grad. cyl. cooler full of water Meteorological data sheet Ground Cover data sheet
Monthly	Calibrate Raingages; Change dessicant in instruments; take in chart from recorders; change battery on wet/dryfall; switch sampler hoses for cleaning	Squirt Bottle; 10 ml Grad. cyl.; dessicant; tape; clean hoses
All trips to the Field		First Aid Kit; tools keys log book pencils weather radio

Table B4. Protocol for Events with unusual sample volume.

One problem encountered with automatic samplers is that they must be programmed for each particular storm. On some occasions, the size of the event was misjudged, and only 2 or 3 aliquots were added to the sample container, and the sample volume was small. In these cases only a limited number of water quality tests could be performed because the sample volume was not large enough to conduct the full suite of analyses. The parameters were ranked in order of priority when only a partial set of analyses was feasible. The following table lists the parameters in order of descending priority:

Volume Required (ml)	Parameter	Cumulative Volume (ml). (amount required is composite container)
250	Suspended Solids	250
25	Total Organic Carbon	275
25	Total Phosphorous	300
500	TKN	800
250	NO_2+NO_3 (dissolved) NO_2 (dissolved) NH_3 (dissolved)	1050
100	Si (dissolved)	1150
300	BOD_5	1450
100	Ortho-phosphorous (dissolved)	1550
200	Alkalinity/pH	1750
500	TKN (dissolved)	2250

At the other extreme, composite containers were sometimes filled to the brim when the expected runoff was underestimated. A float switch then shut the sampler off. In this instance, the time of shut off was unknown, so the sample was classified as a grab, and is recorded as such on the data files and in the summaries in Appendix A. The difficulty in predicting runoff volume is illustrated by two storms which occurred in May 1980 at NPS-5; the rainfall was 0.71

and 1.57 cm for the two events, while respective runoff was 0.64 and 0.03 cm. The larger storm had more than twice the rainfall of the small storm, yet it produced less than one twentieth of the flow of the small storm.

APPENDIX C

EVENT DATA FOR ALL STORMS MONITORED FOR RAINFALL AND RUNOFF QUANTITY AT EACH CATCHMENT

TABLES

TABLE C1. SINGLE LAND USE CATCHMENT

STORM EVENT SUMMARY

STATION:NPS2 LOWLAND AGRICULTURE

EVENT NO.	DATE	RAIN FALL (CM)	RUNOFF: (M3)	RUNOFF: (CM)	RUNOFF COEFFI- CIENT(R)	WATER QUALITY SAMPLES
1	14OCT79	1.02	110.4	0.05	0.045	COMPOSITE
2	12NOV79	8.13	17915	7.45	0.916	COMPOSITE
3	26NOV79	2.46	1653.9	0.69	0.279	COMPOSITE
4	07DEC79	0.79	135.9	0.06	0.072	COMPOSITE
5	21MAY80	1.55	76.5	0.03	0.021	COMPOSITE
6	26OCT80	6.91	104.8	0.04	0.006	COMPOSITE
7	25NOV80	3.56	25.5	0.01	0.003	
8	12FEB81	3.02	376.7	0.16	0.052	COMPOSITE
9	24FEB81	1.78	25.5	0.01	0.006	

TABLE C2. SINGLE LAND USE CATCHMENT

STORM EVENT SUMMARY

STATION:NPS5 LOW DENSITY RESIDENTIAL

EVENT NO.	DATE	RAIN FALL (CM)	RUNOFF: (M3)	(CM)	RUNOFF COEFFI-CIENT(R)	WATER QUALITY SAMPLES
1	02OCT79	1.09	59.2	0.23	0.212	NOT SAMPLED
2	05OCT79	0.58	3.1	0.01	0.021	
3	15OCT79	1.02	29.2	0.11	0.112	NOT SAMPLED
4	04NOV79	8.13	710.0	2.78	0.341	COMPOSITE
5	14NOV79	9.27	2793.8	10.92	1.178	COMPOSITE
6	27NOV79	2.46	291.4	1.14	0.462	COMPOSITE
7	07DEC79	0.79	36.8	0.14	0.183	COMPOSITE
8	14DEC79	1.04	53.5	0.21	0.201	COMPOSITE
9	19JAN80	2.69	559.6	2.19	0.813	COMPOSITE
10	23JAN80	2.03	274.1	1.07	0.527	COMPOSITE
11	11FEB80	1.24	42.8	0.17	0.134	NOT SAMPLED
12	16FEB80	0.63	123.8	0.48	0.762	COMPOSITE
13	23FEB80	0.86	114.1	0.45	0.517	COMPOSITE
14	25FEB80	0.76	90.6	0.35	0.465	NOT SAMPLED
15	14MAR80	3.30	843.9	3.30	0.999	COMPOSITE
16	18MAR80	1.22	166.8	0.65	0.535	COMPOSITE
17	22MAR80	2.59	938.5	3.67	1.416	COMPOSITE
18	25MAR80	1.42	284.6	1.11	0.782	COMPOSITE
19	29MAR80	1.98	329.4	1.29	0.650	COMPOSITE

TABLE C2 (cont.). SINGLE LAND USE CATCHMENT

STORM EVENT SUMMARY

STATION:NPS5 LOW DENSITY RESIDENTIAL

EVENT NO.	DATE	RAIN FALL (CM)	RUNOFF: (M3)	RUNOFF: (CM)	RUNOFF COEFFI- CIENT(R)	WATER QUALITY SAMPLES
20	05APR80	1.24	301.0	1.18	0.946	NOT SAMPLED
21	15APR80	1.45	155.5	0.61	0.420	NOT SAMPLED
22	24APR80	1.30	94.6	0.37	0.285	GRAB
23	26APR80	0.81	38.8	0.15	0.187	NOT SAMPLED
24	28APR80	0.79	117.5	0.46	0.584	COMPOSITE
25	29APR80	0.41	172.5	0.67	1.659	COMPOSITE
26	30APR80	0.46	84.4	0.33	0.722	COMPOSITE
27	01MAY80	0.71	160.6	0.63	0.883	COMPOSITE
28	19MAY80	0.89	0.3	0.00	0.001	
29	21MAY80	1.57	8.2	0.03	0.020	NOT SAMPLED
30	02JUN80	0.69	0.3	0.00	0.002	
31	09JUL80	0.84	0.3	0.00	0.001	
32	14JUL80	2.34	42.2	0.16	0.071	NOT SAMPLED
33	18JUL80	1.88	1.1	0.00	0.002	
34	23JUL80	2.49	1.7	0.01	0.003	
35	06SEP80	3.56	68.5	0.27	0.075	NOT SAMPLED
36	25SEP80	5.13	50.7	0.20	0.039	COMPOSITE
37	13OCT80	1.09	11.0	0.04	0.040	NOT SAMPLED
38	20OCT80	3.28	2.5	0.01	0.003	

TABLE C2 (cont.). SINGLE LAND USE CATCHMENT

STORM EVENT SUMMARY

STATION:NPS5 LOW DENSITY RESIDENTIAL

EVENT NO.	DATE	RAIN FALL (CM)	RUNOFF: (M3)	RUNOFF: (CM)	RUNOFF COEFFI-CIENT(R)	WATER QUALITY SAMPLES
39	26OCT80	5.49	92.3	0.36	0.066	COMPOSITE
40	18NOV80	2.67	27.5	0.11	0.040	COMPOSITE
41	25NOV80	2.18	73.3	0.29	0.131	COMPOSITE
42	02FEB81	1.30	0.6	0.00	0.002	
43	11FEB81	2.72	30.9	0.12	0.044	NOT SAMPLED
44	06MAR81	1.24	18.7	0.07	0.059	NOT SAMPLED
45	06APR81	1.75	4.5	0.02	0.010	
46	21APR81	2.11	14.7	0.06	0.027	NOT SAMPLED
47	20MAY81	1.83	8.8	0.03	0.019	NOT SAMPLED
48	01JUN81	2.36	146.1	0.57	0.242	COMPOSITE
49	21JUN81	2.29	9.6	0.04	0.016	NOT SAMPLED

TABLE C3. SINGLE LAND USE CATCHMENT

STORM EVENT SUMMARY

STATION:NPS7 UPLAND AGRICULTURE

EVENT NO.	DATE	RAIN FALL (CM)	RUNOFF: (M3)	RUNOFF: (CM)	RUNOFF COEFFI- CIENT(R)	WATER QUALITY SAMPLES
1	06SEP79	15.32	5355.3	8.33	0.544	COMPOSITE
2	27SEP79	1.93	14.2	0.02	0.011	
3	01OCT79	0.51	8.5	0.01	0.026	
4	04NOV79	4.78	45.3	0.07	0.015	COMPOSITE
5	14NOV79	8.74	181.2	0.28	0.032	COMPOSITE
6	19JAN80	2.64	19.8	0.03	0.012	COMPOSITE
7	25FEB80	1.17	5.7	0.01	0.008	
8	13MAR80	2.51	19.8	0.03	0.012	NOT SAMPLED
9	22MAR80	2.82	39.6	0.06	0.022	COMPOSITE
10	10APR80	1.65	2.8	0.00	0.003	COMPOSITE
11	28APR80	1.85	31.2	0.05	0.026	COMPOSITE
12	07MAY80	0.48	5.7	0.01	0.018	
13	08JUN80	1.17	2.8	0.00	0.004	
14	23JUL80	7.62	631.5	0.98	0.129	
15	25SEP80	4.50	51.0	0.08	0.018	COMPOSITE
16	26OCT80	4.47	17.0	0.03	0.006	COMPOSITE
17	29MAY81	3.02	39.6	0.06	0.020	COMPOSITE
18	23JUN81	2.44	17.0	0.03	0.011	NOT SAMPLED

TABLE C4. SINGLE LAND USE CATCHMENT

STORM EVENT SUMMARY

STATION:NPS8 UNUSED MIXED FOREST

EVENT NO.	DATE	RAIN FALL (CM)	RUNOFF: (M3)	RUNOFF: (CM)	RUNOFF COEFFI-CIENT(R)	WATER QUALITY SAMPLES
1	07SEP79	15.27	2102.2	2.91	0.191	COMPOSITE
2	24SEP79	9.02	3325.3	4.61	0.511	COMPOSITE
3	14OCT79	1.02	247.0	0.34	0.337	COMPOSITE
4	04NOV79	4.78	682.5	0.95	0.198	COMPOSITE
5	14NOV79	8.69	3949.8	5.47	0.630	COMPOSITE
6	07DEC79	0.36	130.0	0.18	0.507	COMPOSITE
7	14DEC79	1.22	246.1	0.34	0.280	COMPOSITE
8	19JAN80	2.64	638.3	0.88	0.335	COMPOSITE
9	23JAN80	2.16	390.5	0.54	0.251	COMPOSITE
10	16FEB80	0.28	187.8	0.26	0.931	COMPOSITE
11	23FEB80	0.38	180.4	0.25	0.656	COMPOSITE
12	25FEB80	0.79	284.9	0.39	0.501	NOT SAMPLED
13	14MAR80	2.16	611.7	0.85	0.393	COMPOSITE
14	18MAR80	1.50	203.1	0.28	0.188	COMPOSITE
15	22MAR80	2.29	1516.8	2.10	0.919	COMPOSITE
16	25MAR80	0.56	284.0	0.39	0.704	COMPOSITE
17	29MAR80	2.29	287.7	0.40	0.174	COMPOSITE
18	05APR80	2.24	314.9	0.44	0.195	NOT SAMPLED
19	10APR80	1.90	484.0	0.67	0.352	COMPOSITE

TABLE C.4 (cont.). SINGLE LAND USE CATCHMENT

STORM EVENT SUMMARY

STATION:NPS8 UNUSED MIXED FOREST

EVENT NO.	DATE	RAIN FALL (CM)	RUNOFF: (M3)	RUNOFF: (CM)	RUNOFF COEFFI-CIENT(R)	WATER QUALITY SAMPLES
20	15APR80	2.03	471.8	0.65	0.322	COMPOSITE
21	28APR80	2.74	350.6	0.49	0.177	COMPOSITE
22	30APR80	0.63	148.1	0.21	0.323	COMPOSITE
23	01MAY80	4.44	1538.9	2.13	0.480	COMPOSITE
24	21MAY80	4.37	525.3	0.73	0.167	COMPOSITE
25	08JUN80	2.21	135.1	0.19	0.085	NOT SAMPLED
26	14JUL80	2.54	179.3	0.25	0.098	NOT SAMPLED
27	23JUL80	9.93	384.3	0.53	0.054	COMPOSITE
28	06AUG80	3.68	186.3	0.26	0.070	NOT SAMPLED
29	06SEP80	1.57	13.3	0.02	0.012	
30	25SEP80	4.85	36.2	0.05	0.010	COMPOSITE
31	20OCT80	3.40	77.6	0.11	0.032	NOT SAMPLED
32	26OCT80	4.44	136.8	0.19	0.043	NOT SAMPLED
33	18NOV80	2.67	58.3	0.08	0.030	COMPOSITE
34	24FEB81	1.32	57.8	0.08	0.061	NOT SAMPLED
35	20MAY81	2.79	79.9	0.11	0.040	NOT SAMPLED
36	29MAY81	4.80	113.6	0.16	0.033	COMPOSITE
37	21JUN81	4.24	36.8	0.05	0.012	

APPENDIX D

COMPOSITE WATER QUALITY DATA FOR ALL STORMS MONITORED FOR POLLUTANT LOADING

TABLES

TABLE D1.

SINGLE LAND USE CATCHMENT

STORM EVENT COMPOSITE SAMPLING SUMMARY

STATION:NPS2 LOWLAND AGRICULTURE

DATE(S)	RAIN FALL CM	RUNOFF M3	SUSP SOLIDS MG/L	BOD5 MG/L	INHIB BOD5 MG/L	DISS SILICA MG/L	ALKA-LINITY MG/L	PH	DISS OXYGEN MG/L	TEMP CELSIUS
14OCT79	1.02	110.4	23.0	.	.	.	94.0	6.60	8.30	11.4
	TOTAL RAINFALL (CM): 1.02						TOTAL RUNOFF (M3): 110.4			
12NOV79	8.13	17915	167.0	6.40	4.40	.	43.0	6.40	8.20	12.0
	TOTAL RAINFALL (CM): 8.13						TOTAL RUNOFF (M3): 17915			
26NOV79	2.46	1653.9	130.5	5.70	5.40	2.00	38.0	6.60	5.70	16.9
	TOTAL RAINFALL (CM): 2.46						TOTAL RUNOFF (M3): 1653.9			
07DEC79	0.79	135.9	28.0	.	.	3.20	.	.	.	.
	TOTAL RAINFALL (CM): 0.79						TOTAL RUNOFF (M3): 135.9			
21MAY80	1.55	76.5	8.5	4.65	.	3.35	.	.	8.48	.
	TOTAL RAINFALL (CM): 1.55						TOTAL RUNOFF (M3): 76.5			

SINGLE LAND USE CATCHMENT

STORM EVENT COMPOSITE SAMPLING SUMMARY

STATION:NPS2 LOWLAND AGRICULTURE

DATE(S)	RAIN FALL CM	RUNOFF M3	SUSP SOLIDS MG/L	BOD5 MG/L	INHIB BOD5 MG/L	DISS SILICA MG/L	ALKA-LINITY MG/L	PH	DISS OXYGEN MG/L	TEMP CELSIUS
26OCT80	6.91	104.8	1022.0	.	.	.	.	.	.	.
TOTAL RAINFALL (CM): 6.91						TOTAL RUNOFF (M3): 104.8				
11FEB81	2.62	150.1	149.0	.	3.60	1.94	.	.	.	.
12FEB81	0.41	226.6	58.0	.	2.55	2.07	.	.	.	.
TOTAL RAINFALL (CM): 3.02						TOTAL RUNOFF (M3): 376.7				

TABLE D1 (Continued)

SINGLE LAND USE CATCHMENT

STORM EVENT COMPOSITE SAMPLING SUMMARY

STATION:NPS2 LOWLAND AGRICULTURE

DATE(S)	RAIN FALL CM	RUNOFF M3	TOTAL PHOS MG/L	ORTHO PHOS MG/L	FILTRD TOTL*PHOS MG/L	TKN MG/L	FILTRD TKN MG/L	NH3 MG/L	FILTRD NH3 MG/L	NO2+ NO3 MG/L	NO2 MG/L	INORG N MG/L	ORGAN N MG/L
14OCT79	1.02	110.4	0.16	0.00	0.06	0.61	0.40	0.00	0.00	0.03	.	0.03	0.61
	TOTAL RAINFALL (CM): 1.02						TOTAL RUNOFF (M3): 110.4						
12NOV79	8.13	17915	0.73	0.41	0.44	1.31	0.42	0.11	0.00	0.00	.	0.00	1.20
	TOTAL RAINFALL (CM): 8.13						TOTAL RUNOFF (M3): 17915						
26NOV79	2.46	1653.9	0.77	0.42	0.45	1.40	0.50	0.10	0.00	0.09	.	0.09	1.30
	TOTAL RAINFALL (CM): 2.46						TOTAL RUNOFF (M3): 1653.9						
07DEC79	0.79	135.9	0.21	0.04	0.08	.	.	.	0.04	0.10	.	0.14	.
	TOTAL RAINFALL (CM): 0.79						TOTAL RUNOFF (M3): 135.9						
21MAY80	1.55	76.5	0.13	0.06	.	0.83	.	.	0.11	1.44	0.01	1.55	.
	TOTAL RAINFALL (CM): 1.55						TOTAL RUNOFF (M3): 76.5						

TABLE D1 (Continued)

SINGLE LAND USE CATCHMENT

STORM EVENT COMPOSITE SAMPLING SUMMARY

STATION:NPS2 LOWLAND AGRICULTURE

DATE(S)	RAIN FALL CM	RUNOFF M3	TOTAL PHOS MG/L	ORTHO PHOS MG/L	FILTRD TOTL*PHOS MG/L	TKN MG/L	FILTRD TKN MG/L	NH3 MG/L	FILTRD NH3 MG/L	NO2+ NO3 MG/L	NO2 MG/L	INORG N MG/L	ORGAN N MG/L
26OCT80	6.91	104.8	2.04	.	.	.	.	.	.	.	.	.	.
	TOTAL RAINFALL (CM): 6.91						TOTAL RUNOFF (M3):			104.8			
11FEB81	2.62	150.1	0.50	0.01	.	3.21	0.62	.	0.00	1.05	0.01	1.05	.
12FEB81	0.41	226.6	0.33	0.02	.	2.33	0.75	.	0.01	1.78	0.02	1.79	.
	TOTAL RAINFALL (CM): 3.02						TOTAL RUNOFF (M3):			376.7			

TABLE D2.

SINGLE LAND USE CATCHMENT

STORM EVENT COMPOSITE SAMPLING SUMMARY

STATION:NPS5   LOW DENSITY RESIDENTIAL

DATE(S)	RAIN FALL CM	RUNOFF M3	SUSP SOLIDS MG/L	BOD5 MG/L	INHIB BOD5 MG/L	DISS SILICA MG/L	ALKA-LINITY MG/L	PH	DISS OXYGEN MG/L	TEMP CELSIUS
03NOV79	3.15	61.5	128.0	.	.	0.55	6.0	5.50	.	12.2
04NOV79	4.98	648.5	27.0	1.50	1.10	3.20	.	.	9.22	12.2
	TOTAL RAINFALL (CM): 8.13						TOTAL RUNOFF (M3): 710.0			
12NOV79	8.03	1631.2	6.0	2.00	0.70	6.40	2.0	5.40	6.90	14.0
14NOV79	1.24	1162.5	3.0	0.60	0.40	4.60	2.3	5.20	9.60	.
	TOTAL RAINFALL (CM): 9.27						TOTAL RUNOFF (M3): 2793.8			
26NOV79	2.46	153.2	131.0	6.10	6.10	2.00	39.0	6.90	7.60	16.5
27NOV79	0.00	138.2	3.0	2.20	1.60	5.60	.	.	.	.
	TOTAL RAINFALL (CM): 2.46						TOTAL RUNOFF (M3): 291.4			
07DEC79	0.79	36.8	38.0	.	.	3.80	.	.	.	.
	TOTAL RAINFALL (CM): 0.79						TOTAL RUNOFF (M3): 36.8			

TABLE D2 (Continued)

SINGLE LAND USE CATCHMENT

STORM EVENT COMPOSITE SAMPLING SUMMARY

STATION:NPS5   LOW DENSITY RESIDENTIAL

DATE(S)	RAIN FALL CM	RUNOFF M3	SUSP SOLIDS MG/L	BOD5 MG/L	INHIB BOD5 MG/L	DISS SILICA MG/L	ALKA-LINITY MG/L	PH	DISS OXYGEN MG/L	TEMP CELSIUS
14DEC79	1.04	53.5	14.0	0.60	0.40	3.66	.	.	10.29	7.5
	TOTAL RAINFALL (CM): 1.04						TOTAL RUNOFF (M3):		53.5	
19JAN80	2.69	559.6	25.5	1.80	0.90	3.86	2.4	5.28	.	7.0
	TOTAL RAINFALL (CM): 2.69						TOTAL RUNOFF (M3):		559.6	
23JAN80	2.03	274.1	10.0	1.40	0.80	3.88	.	.	8.41	7.0
	TOTAL RAINFALL (CM): 2.03						TOTAL RUNOFF (M3):		274.1	
16FEB80	0.63	123.8	50.0	3.45	2.30	3.88	4.5	5.26	9.90	.
	TOTAL RAINFALL (CM): 0.63						TOTAL RUNOFF (M3):		123.8	
23FEB80	0.86	114.1	19.0	2.65	2.00	0.31	15.5	5.34	9.76	8.5
	TOTAL RAINFALL (CM): 0.86						TOTAL RUNOFF (M3):		114.1	

TABLE D2 (Continued)

SINGLE LAND USE CATCHMENT

STORM EVENT COMPOSITE SAMPLING SUMMARY

STATION:NPS5 LOW DENSITY RESIDENTIAL

DATE(S)	RAIN FALL CM	RUNOFF M3	SUSP SOLIDS MG/L	BOD5 MG/L	INHIB BOD5 MG/L	DISS SILICA MG/L	ALKA-LINITY MG/L	PH	DISS OXYGEN MG/L	TEMP CELSIUS
14MAR80	3.30	843.9	85.5	0.95	1.45	2.65	0.4	4.58	.	.
	TOTAL RAINFALL (CM): 3.30						TOTAL RUNOFF (M3): 843.9			
18MAR80	1.22	166.8	63.0	2.20	1.30	2.96	66.4	6.53	8.30	.
	TOTAL RAINFALL (CM): 1.22						TOTAL RUNOFF (M3): 166.8			
22MAR80	2.59	938.5	30.0	1.10	0.80	3.16	0.5	4.52	.	.
	TOTAL RAINFALL (CM): 2.59						TOTAL RUNOFF (M3): 938.5			
25MAR80	1.42	284.6	60.0	2.00	1.65	3.59	1.8	5.43	9.63	.
	TOTAL RAINFALL (CM): 1.42						TOTAL RUNOFF (M3): 284.6			
29MAR80	1.98	329.4	43.0	1.40	0.80	3.64	0.0	3.60	9.57	.
	TOTAL RAINFALL (CM): 1.98						TOTAL RUNOFF (M3): 329.4			

SINGLE LAND USE CATCHMENT

STORM EVENT COMPOSITE SAMPLING SUMMARY

STATION:NPS5 LOW DENSITY RESIDENTIAL

DATE(S)	RAIN FALL CM	RUNOFF M3	SUSP SOLIDS MG/L	BOD5 MG/L	INHIB BOD5 MG/L	DISS SILICA MG/L	ALKA-LINITY MG/L	PH	DISS OXYGEN MG/L	TEMP CELSIUS
28APR80	0.79	117.5	111.0	4.85	5.10	3.22	0.0	2.86	7.08	17.0
	TOTAL RAINFALL (CM): 0.79					TOTAL RUNOFF (M3): 117.5				
29APR80	0.41	172.5	.	2.50	1.65	5.72	2.5	5.57	7.50	23.0
	TOTAL RAINFALL (CM): 0.41					TOTAL RUNOFF (M3): 172.5				
30APR80	0.46	84.4	37.0	2.70	.	5.19	5.0	6.50	8.18	15.0
	TOTAL RAINFALL (CM): 0.46					TOTAL RUNOFF (M3): 84.4				
01MAY80	0.71	160.6	14.0	1.50	0.90	5.29	2.1	5.27	8.16	15.5
	TOTAL RAINFALL (CM): 0.71					TOTAL RUNOFF (M3): 160.6				
25SEP80	5.13	50.7	118.0	.	.	0.39	.	.	.	.
	TOTAL RAINFALL (CM): 5.13					TOTAL RUNOFF (M3): 50.7				

TABLE D2 (Continued)

SINGLE LAND USE CATCHMENT

STORM EVENT COMPOSITE SAMPLING SUMMARY

STATION:NPS5 LOW DENSITY RESIDENTIAL

DATE(S)	RAIN FALL CM	RUNOFF M3	SUSP SOLIDS MG/L	BOD5 MG/L	INHIB BOD5 MG/L	DISS SILICA MG/L	ALKA-LINITY MG/L	PH	DISS OXYGEN MG/L	TEMP CELSIUS
26OCT80	5.49	92.3	199.0	3.80	.	0.52	.	.	.	.
TOTAL RAINFALL (CM): 5.49						TOTAL RUNOFF (M3): 92.3				
18NOV80	2.67	27.5	88.0	.	.	.	.	.	.	.
TOTAL RAINFALL (CM): 2.67						TOTAL RUNOFF (M3): 27.5				
25NOV80	2.18	73.3	40.0	10.85	.	.	.	.	.	.
TOTAL RAINFALL (CM): 2.18						TOTAL RUNOFF (M3): 73.3				
01JUN81	2.36	146.1	.	.	4.10	0.07	5.0	5.40	.	.
TOTAL RAINFALL (CM): 2.36						TOTAL RUNOFF (M3): 146.1				

TABLE D 2 (Continued)

SINGLE LAND USE CATCHMENT

STORM EVENT COMPOSITE SAMPLING SUMMARY

STATION:NFS5 LOW DENSITY RESIDENTIAL

DATE(S)	RAIN FALL CM	RUNOFF M3	TOTAL PHOS MG/L	ORTHO PHOS MG/L	FILTRD TOTL*PHOS MG/L	TKN MG/L	FILTRD TKN MG/L	NH3 MG/L	FILTRD NH3 MG/L	NO2+ NO3 MG/L	NO2 MG/L	INORG N MG/L	ORGAN N MG/L
03NOV79	3.15	61.5	0.34	0.14	0.15	0.54	0.28	0.00	0.07	0.11	.	0.18	0.54
04NOV79	4.98	648.5	0.18	0.05	0.07	0.54	0.18	0.12	0.00	0.42	.	0.42	0.42
TOTAL RAINFALL (CM): 8.13						TOTAL RUNOFF (M3): 710.0							
12NOV79	8.03	1631.2	0.06	0.00	0.00	0.15	0.18	0.00	0.00	0.00	.	0.00	0.15
14NOV79	1.24	1162.5	0.08	0.05	0.06	0.28	0.20	0.00	0.00	0.51	.	0.51	0.28
TOTAL RAINFALL (CM): 9.27						TOTAL RUNOFF (M3): 2793.8							
26NOV79	2.46	153.2	0.72	0.42	0.47	1.35	0.52	0.15	0.05	0.09	.	0.14	1.20
27NOV79	0.00	138.2	0.00	0.00	0.00	0.19	0.15	0.00	0.00	0.45	.	0.45	0.19
TOTAL RAINFALL (CM): 2.46						TOTAL RUNOFF (M3): 291.4							
07DEC79	0.79	36.8	0.13	0.00	0.05	.	.	.	0.03	0.07	.	0.10	.
TOTAL RAINFALL (CM): 0.79						TOTAL RUNOFF (M3): 36.8							

TABLE D 2 (Continued)

SINGLE LAND USE CATCHMENT

STORM EVENT COMPOSITE SAMPLING SUMMARY

STATION:NPS5   LOW DENSITY RESIDENTIAL

DATE(S)	RAIN FALL CM	RUNOFF M3	TOTAL PHOS MG/L	ORTHO PHOS MG/L	FILTRD TOTL*PHOS MG/L	TKN MG/L	FILTRD TKN MG/L	NH3 MG/L	FILTRD NH3 MG/L	NO2+ NO3 MG/L	NO2 MG/L	INORG N MG/L	ORGAN N MG/L
14DEC79	1.04	53.5	0.12	0.01	0.00	.	.	.	.	0.06	.	.	.
	TOTAL RAINFALL (CM): 1.04						TOTAL RUNOFF (M3): 53.5						
19JAN80	2.69	559.6	0.08	0.02	0.00	0.25	0.28	0.00	0.00	0.48	.	0.48	0.25
	TOTAL RAINFALL (CM): 2.69						TOTAL RUNOFF (M3): 559.6						
23JAN80	2.03	274.1	0.05	0.01	0.00	0.24	0.15	0.00	0.00	0.69	.	0.69	0.24
	TOTAL RAINFALL (CM): 2.03						TOTAL RUNOFF (M3): 274.1						
16FEB80	0.63	123.8	0.08	0.00	0.11	0.28	0.18	0.00	0.05	0.25	.	0.30	0.28
	TOTAL RAINFALL (CM): 0.63						TOTAL RUNOFF (M3): 123.8						
23FEB80	0.86	114.1	0.08	0.00	0.00	0.18	0.22	0.00	0.00	0.22	.	0.22	0.18
	TOTAL RAINFALL (CM): 0.86						TOTAL RUNOFF (M3): 114.1						

TABLE D2 (Continued)

SINGLE LAND USE CATCHMENT

STORM EVENT COMPOSITE SAMPLING SUMMARY

STATION:NPS5 LOW DENSITY RESIDENTIAL

DATE(S)	RAIN FALL CM	RUNOFF M3	TOTAL PHOS MG/L	ORTHO PHOS MG/L	FILTRD TOTL*PHOS MG/L	TKN MG/L	FILTRD TKN MG/L	NH3 MG/L	FILTRD NH3 MG/L	NO2+ NO3 MG/L	NO2 MG/L	INORG N MG/L	ORGAN N MG/L
14MAR80	3.30	843.9	0.11	0.01	0.00	0.48	0.22	0.00	0.00	0.41	.	0.41	0.48
	TOTAL RAINFALL (CM): 3.30						TOTAL RUNOFF (M3): 843.9						
18MAR80	1.22	166.8	0.21	0.04	.	.	1.51	0.00	0.38	0.48	.	0.86	.
	TOTAL RAINFALL (CM): 1.22						TOTAL RUNOFF (M3): 166.8						
22MAR80	2.59	938.5	0.15	0.01	0.00	0.45	0.22	0.00	0.00	0.44	.	0.44	0.45
	TOTAL RAINFALL (CM): 2.59						TOTAL RUNOFF (M3): 938.5						
25MAR80	1.42	284.6	0.18	0.03	0.00	0.42	0.18	0.00	0.07	0.34	.	0.41	0.42
	TOTAL RAINFALL (CM): 1.42						TOTAL RUNOFF (M3): 284.6						
29MAR80	1.98	329.4	0.09	0.01	0.00	0.40	0.20	0.00	0.00	0.44	.	0.44	0.35
	TOTAL RAINFALL (CM): 1.98						TOTAL RUNOFF (M3): 329.4						

TABLE D2 (Continued)

SINGLE LAND USE CATCHMENT

STORM EVENT COMPOSITE SAMPLING SUMMARY

STATION:NFS5   LOW DENSITY RESIDENTIAL

DATE(S)	RAIN FALL CM	RUNOFF M3	TOTAL PHOS MG/L	ORTHO PHOS MG/L	FILTRD TOTL*PHOS MG/L	TKN MG/L	FILTRD TKN MG/L	NH3 MG/L	FILTRD NH3 MG/L	NO2+ NO3 MG/L	NO2 MG/L	INORG N MG/L	ORGAN N MG/L
28APR80	0.79	117.5	0.22	0.03	0.00	1.20	0.42	0.18	0.00	.	.	.	1.02
	TOTAL RAINFALL (CM): 0.79						TOTAL RUNOFF (M3): 117.5						
29APR80	0.41	172.5	0.10	0.01	.	0.42	.	0.00	0.00	.	.	.	.
	TOTAL RAINFALL (CM): 0.41						TOTAL RUNOFF (M3): 172.5						
30APR80	0.46	84.4	0.08	0.00	.	0.45	.	0.00	0.00	.	.	.	.
	TOTAL RAINFALL (CM): 0.46						TOTAL RUNOFF (M3): 84.4						
01MAY80	0.71	160.6	0.00	0.00	0.00	0.28	0.20	0.00	0.00	.	.	.	0.28
	TOTAL RAINFALL (CM): 0.71						TOTAL RUNOFF (M3): 160.6						
25SEP80	5.13	50.7	0.73	0.35	.	2.43	.	.	0.18	0.35	0.00	0.53	.
	TOTAL RAINFALL (CM): 5.13						TOTAL RUNOFF (M3): 50.7						

TABLE D2 (Continued)

SINGLE LAND USE CATCHMENT

STORM EVENT COMPOSITE SAMPLING SUMMARY

STATION:NPS5 LOW DENSITY RESIDENTIAL

DATE(S)	RAIN FALL CM	RUNOFF M3	TOTAL PHOS MG/L	ORTHO PHOS MG/L	FILTRD TOTL*PHOS MG/L	TKN MG/L	FILTRD TKN MG/L	NH3 MG/L	FILTRD NH3 MG/L	NO2+ NO3 MG/L	NO2 MG/L	INORG N MG/L	ORGAN N MG/L
26OCT80	5.49	92.3	0.51	0.14	.	1.59	0.32	.	0.01	0.14	0.00	0.15	.
	TOTAL RAINFALL (CM): 5.49						TOTAL RUNOFF (M3): 92.3						
18NOV80	2.67	27.5	0.54	.	.	1.16	.	.	.	.	.	.	.
	TOTAL RAINFALL (CM): 2.67						TOTAL RUNOFF (M3): 27.5						
25NOV80	2.18	73.3	0.54	0.26	.	0.90	0.40	.	0.01	0.00	0.00	0.01	.
	TOTAL RAINFALL (CM): 2.18						TOTAL RUNOFF (M3): 73.3						
01JUN81	2.36	146.1	0.11	0.11	.	1.80	0.63	.	0.04	0.21	0.01	0.25	.
	TOTAL RAINFALL (CM): 2.36						TOTAL RUNOFF (M3): 146.1						

TABLE D3.

SINGLE LAND USE CATCHMENT

STORM EVENT COMPOSITE SAMPLING SUMMARY

STATION:NPS7 UPLAND AGRICULTURE

DATE(S)	RAIN FALL CM	RUNOFF M3	SUSP SOLIDS MG/L	BOD5 MG/L	INHIB BOD5 MG/L	DISS SILICA MG/L	ALKA-LINITY MG/L	PH	DISS OXYGEN MG/L	TEMP CELSIUS
06SEP79	15.32	5355.3	170.0	8.10	8.10	.	9.0	5.70	.	.
	TOTAL RAINFALL (CM):15.32					TOTAL RUNOFF (M3): 5355.3				
04NOV79	4.78	45.3	29.0	.	.	0.90	.	.	.	.
	TOTAL RAINFALL (CM): 4.78					TOTAL RUNOFF (M3): 45.3				
12NOV79	6.65	155.8	23.0	7.00	5.10	0.52	21.0	6.60	8.60	.
14NOV79	2.08	25.5	12.0	.	.	.	.	.	.	.
	TOTAL RAINFALL (CM): 8.74					TOTAL RUNOFF (M3): 181.2				
19JAN80	2.64	19.8	183.7	.	.	0.57	.	.	.	7.0
	TOTAL RAINFALL (CM): 2.64					TOTAL RUNOFF (M3): 19.8				
22MAR80	2.82	39.6	315.0	6.10	5.50	0.52	11.0	5.77	.	.
	TOTAL RAINFALL (CM): 2.82					TOTAL RUNOFF (M3): 39.6				

SINGLE LAND USE CATCHMENT

STORM EVENT COMPOSITE SAMPLING SUMMARY

STATION:NPS7   UPLAND AGRICULTURE

DATE(S)	RAIN FALL CM	RUNOFF M3	SUSP SOLIDS MG/L	BOD5 MG/L	INHIB BOD5 MG/L	DISS SILICA MG/L	ALKA-LINITY MG/L	PH	DISS OXYGEN MG/L	TEMP CELSIUS
10APR80	1.65	2.8	664.0	.	.	0.50	.	.	.	.
	TOTAL RAINFALL (CM): 1.65						TOTAL RUNOFF (M3):			2.8
28APR80	1.85	31.2	1634.0	5.55	5.70	0.43	0.0	3.48	.	.
	TOTAL RAINFALL (CM): 1.85						TOTAL RUNOFF (M3):			31.2
25SEP80	4.50	51.0	1954.0	5.55	.	0.28	.	.	.	.
	TOTAL RAINFALL (CM): 4.50						TOTAL RUNOFF (M3):			51.0
26OCT80	4.47	17.0	519.0	.	.	0.51	.	.	.	.
	TOTAL RAINFALL (CM): 4.47						TOTAL RUNOFF (M3):			17.0
29MAY81	3.02	39.6	4010.0	.	6.30	0.32	12.5	5.57	.	.
	TOTAL RAINFALL (CM): 3.02						TOTAL RUNOFF (M3):			39.6

TABLE D 3 (Continued)

SINGLE LAND USE CATCHMENT

STORM EVENT COMPOSITE SAMPLING SUMMARY

STATION:NPS7 UPLAND AGRICULTURE

DATE(S)	RAIN FALL CM	RUNOFF M3	TOTAL PHOS MG/L	ORTHO PHOS MG/L	FILTRD TOTL*PHOS MG/L	TKN MG/L	FILTRD TKN MG/L	NH3 MG/L	FILTRD NH3 MG/L	NO2+ NO3 MG/L	NO2 MG/L	INORG N MG/L	ORGAN N MG/L
06SEP79	15.32	5355.3	0.51	0.26	0.40	1.15	0.45	0.00	0.00	0.00	.	0.00	1.15
	TOTAL RAINFALL (CM):15.32						TOTAL RUNOFF (M3): 5355.3						
04NOV79	4.78	45.3	1.32	0.72	0.80	1.35	.	0.15	0.00	0.26	.	0.26	1.20
	TOTAL RAINFALL (CM): 4.78						TOTAL RUNOFF (M3): 45.3						
12NOV79	6.65	155.8	0.86	0.63	0.68	1.08	0.60	0.10	0.00	0.15	.	0.15	0.98
14NOV79	2.08	25.5	0.72	0.51	0.62	.	.	.	0.00	0.00	.	0.00	.
	TOTAL RAINFALL (CM): 8.74						TOTAL RUNOFF (M3): 181.2						
19JAN80	2.64	19.8	1.12	0.26	0.31	1.72	0.58	0.10	0.00	0.26	.	0.26	1.62
	TOTAL RAINFALL (CM): 2.64						TOTAL RUNOFF (M3): 19.8						
22MAR80	2.82	39.6	2.15	0.20	0.23	2.15	0.55	0.10	0.00	0.13	.	0.13	2.05
	TOTAL RAINFALL (CM): 2.82						TOTAL RUNOFF (M3): 39.6						

TABLE D3 (Continued)

SINGLE LAND USE CATCHMENT

STORM EVENT COMPOSITE SAMPLING SUMMARY

STATION:NPS7 UPLAND AGRICULTURE

DATE(S)	RAIN FALL CM	RUNOFF M3	TOTAL PHOS MG/L	ORTHO PHOS MG/L	FILTRD TOTL*PHOS MG/L	TKN MG/L	FILTRD TKN MG/L	NH3 MG/L	FILTRD NH3 MG/L	NO2+ NO3 MG/L	NO2 MG/L	INORG N MG/L	ORGAN N MG/L
10APR80	1.65	2.8	3.48	0.86	1.18	.	.	.	0.16	0.58	.	0.74	.
TOTAL RAINFALL (CM): 1.65						TOTAL RUNOFF (M3): 2.8							
28APR80	1.85	31.2	5.19	0.61	.	5.25	.	0.00	0.05	.	.	.	.
TOTAL RAINFALL (CM): 1.85						TOTAL RUNOFF (M3): 31.2							
25SEP80	4.50	51.0	3.15	0.31	.	7.15	1.35	.	0.03	0.36	0.00	0.39	.
TOTAL RAINFALL (CM): 4.50						TOTAL RUNOFF (M3): 51.0							
26OCT80	4.47	17.0	1.32	0.24	.	2.36	.	.	0.00	0.09	0.00	0.09	.
TOTAL RAINFALL (CM): 4.47						TOTAL RUNOFF (M3): 17.0							
29MAY81	3.02	39.6	4.92	0.54	.	13.6	2.42	.	.	2.32	0.08	.	.
TOTAL RAINFALL (CM): 3.02						TOTAL RUNOFF (M3): 39.6							

TABLE D 4.

SINGLE LAND USE CATCHMENT

STORM EVENT COMPOSITE SAMPLING SUMMARY

STATION:NPS8 UNUSED MIXED FOREST

DATE(S)	RAIN FALL CM	RUNOFF M3	SUSP SOLIDS MG/L	BOD5 MG/L	INHIB BOD5 MG/L	DISS SILICA MG/L	ALKA-LINITY MG/L	PH	DISS OXYGEN MG/L	TEMP CELSIUS
05SEP79	7.16	241.0	137.0	3.40	3.40	.	0.0	4.10	6.00	22.8
06SEP79	8.10	808.3	101.0	2.40	2.00	.	0.0	3.30	5.30	23.0
07SEP79	0.00	1052.9	1.0	2.30	1.50	1.36	0.0	4.50	6.40	22.0
	TOTAL RAINFALL (CM):15.27						TOTAL RUNOFF (M3): 2102.2			
22SEP79	7.09	2121.7	98.0	2.20	1.80	.	.	.	.	.
24SEP79	0.84	1203.6	52.0	0.85	1.40	.	.	.	.	.
	TOTAL RAINFALL (CM): 7.92						TOTAL RUNOFF (M3): 3325.3			
14OCT79	1.02	247.0	0.0	.	.	.	1.9	4.80	8.10	13.8
	TOTAL RAINFALL (CM): 1.02						TOTAL RUNOFF (M3): 247.0			
04NOV79	4.78	682.5	56.0	1.20	2.00	2.80	.	.	8.16	12.5
	TOTAL RAINFALL (CM): 4.78						TOTAL RUNOFF (M3): 682.5			

TABLE D4 (Continued)

SINGLE LAND USE CATCHMENT

STORM EVENT COMPOSITE SAMPLING SUMMARY

STATION:NPS8 UNUSED MIXED FOREST

DATE(S)	RAIN FALL CM	RUNOFF M3	SUSP SOLIDS MG/L	BOD5 MG/L	INHIB BOD5 MG/L	DISS SILICA MG/L	ALKA-LINITY MG/L	PH	DISS OXYGEN MG/L	TEMP CELSIUS
12NOV79	7.39	2063.4	1.0	0.50	0.30	2.00	0.0	4.40	7.60	.
14NOV79	1.30	1886.4	12.0	.	.	.	0.0	4.20	8.00	.
	TOTAL RAINFALL (CM): 8.69						TOTAL RUNOFF (M3): 3949.8			
07DEC79	0.36	130.0	17.0	.	.	3.00	.	.	.	.
	TOTAL RAINFALL (CM): 0.36						TOTAL RUNOFF (M3): 130.0			
14DEC79	1.22	246.1	14.0	0.15	0.00	3.48	.	.	9.24	9.0
	TOTAL RAINFALL (CM): 1.22						TOTAL RUNOFF (M3): 246.1			
19JAN80	2.64	638.3	22.5	0.50	0.30	2.46	1.2	4.84	9.04	7.0
	TOTAL RAINFALL (CM): 2.64						TOTAL RUNOFF (M3): 638.3			
23JAN80	2.16	390.5	0.5	0.50	0.30	2.43	0.0	3.78	9.31	8.0
	TOTAL RAINFALL (CM): 2.16						TOTAL RUNOFF (M3): 390.5			

TABLE D4 (Continued)

SINGLE LAND USE CATCHMENT

STORM EVENT COMPOSITE SAMPLING SUMMARY

STATION:NPS8 UNUSED MIXED FOREST

DATE(S)	RAIN FALL CM	RUNOFF M3	SUSP SOLIDS MG/L	BOD5 MG/L	INHIB BOD5 MG/L	DISS SILICA MG/L	ALKA-LINITY MG/L	PH	DISS OXYGEN MG/L	TEMP CELSIUS
16FEB80	0.28	187.8	7.0	.	.	2.96	.	.	10.48	.
	TOTAL RAINFALL (CM): 0.28						TOTAL RUNOFF (M3): 187.8			
23FEB80	0.38	180.4	9.5	1.75	1.50	0.22	10.8	5.95	.	8.0
	TOTAL RAINFALL (CM): 0.38						TOTAL RUNOFF (M3): 180.4			
14MAR80	2.16	611.7	71.0	1.15	0.80	2.06	0.0	3.98	.	.
	TOTAL RAINFALL (CM): 2.16						TOTAL RUNOFF (M3): 611.7			
18MAR80	1.50	203.1	26.0	0.40	0.20	2.34	0.4	4.54	8.90	.
	TOTAL RAINFALL (CM): 1.50						TOTAL RUNOFF (M3): 203.1			
22MAR80	2.29	1516.8	73.0	1.00	0.70	1.93	0.0	3.29	.	.
	TOTAL RAINFALL (CM): 2.29						TOTAL RUNOFF (M3): 1516.8			

TABLE D4 (Continued)

SINGLE LAND USE CATCHMENT

STORM EVENT COMPOSITE SAMPLING SUMMARY

STATION:NPS8 UNUSED MIXED FOREST

DATE(S)	RAIN FALL CM	RUNOFF M3	SUSP SOLIDS MG/L	BOD5 MG/L	INHIB BOD5 MG/L	DISS SILICA MG/L	ALKA-LINITY MG/L	PH	DISS OXYGEN MG/L	TEMP CELSIUS
25MAR80	0.56	284.0	0.0	1.00	1.00	2.75	0.8	5.04	9.25	.
	TOTAL RAINFALL (CM): 0.56					TOTAL RUNOFF (M3):	284.0			
29MAR80	2.27	287.7	15.0	0.50	0.35	2.63	0.7	4.77	9.23	.
	TOTAL RAINFALL (CM): 2.27					TOTAL RUNOFF (M3):	287.7			
10APR80	1.90	484.0	26.0	0.90	0.50	2.60	0.4	4.64	.	.
	TOTAL RAINFALL (CM): 1.90					TOTAL RUNOFF (M3):	484.0			
15APR80	2.03	471.8	11.0	0.50	0.70	2.70	0.8	4.73	8.60	.
	TOTAL RAINFALL (CM): 2.03					TOTAL RUNOFF (M3):	471.8			
28APR80	2.74	350.6	82.0	1.50	1.05	2.81	0.0	4.43	8.02	14.5
	TOTAL RAINFALL (CM): 2.74					TOTAL RUNOFF (M3):	350.6			

TABLE D4 (Continued)

SINGLE LAND USE CATCHMENT

STORM EVENT COMPOSITE SAMPLING SUMMARY

STATION:NPS8 UNUSED MIXED FOREST

DATE(S)	RAIN FALL CM	RUNOFF M3	SUSP SOLIDS MG/L	BOD5 MG/L	INHIB BOD5 MG/L	DISS SILICA MG/L	ALKA-LINITY MG/L	PH	DISS OXYGEN MG/L	TEMP CELSIUS
30APR80	0.63	148.1	12.0	0.90	.	3.83	2.8	5.86	8.22	13.8
	TOTAL RAINFALL (CM): 0.63						TOTAL RUNOFF (M3): 148.1			
01MAY80	4.44	1538.9	373.0	3.10	2.20	1.56	0.0	4.11	7.72	.
	TOTAL RAINFALL (CM): 4.44						TOTAL RUNOFF (M3): 1538.9			
20MAY80	2.18	212.1	44.0	3.30	2.05	2.58	.	.	7.48	.
21MAY80	2.18	313.2	0.6	1.30	1.05	2.91	0.0	4.73	7.51	.
	TOTAL RAINFALL (CM): 4.37						TOTAL RUNOFF (M3): 525.3			
23JUL80	9.93	384.3	121.0	3.05	1.60	0.01	.	.	.	22.0
	TOTAL RAINFALL (CM): 9.93						TOTAL RUNOFF (M3): 384.3			
25SEP80	4.85	36.2	.	.	.	3.34	.	.	6.63	.
	TOTAL RAINFALL (CM): 4.85						TOTAL RUNOFF (M3): 36.2			

TABLE D4 (Continued)

SINGLE LAND USE CATCHMENT

STORM EVENT COMPOSITE SAMPLING SUMMARY

STATION:NPS8 UNUSED MIXED FOREST

DATE(S)	RAIN FALL CM	RUNOFF M3	SUSP SOLIDS MG/L	BOD5 MG/L	INHIB BOD5 MG/L	DISS SILICA MG/L	ALKA-LINITY MG/L	PH	DISS OXYGEN MG/L	TEMP CELSIUS
18NOV80	2.67	58.3	57.0	.	.	.	.	.	.	.
	TOTAL RAINFALL (CM): 2.67					TOTAL RUNOFF (M3): 58.3				
29MAY81	4.80	113.6	42.0	.	3.60	0.22	4.5	5.20	.	.
	TOTAL RAINFALL (CM): 4.80					TOTAL RUNOFF (M3): 113.6				

TABLE D4 (Continued)

SINGLE LAND USE CATCHMENT

STORM EVENT COMPOSITE SAMPLING SUMMARY

STATION:NPS8 UNUSED MIXED FOREST

DATE(S)	RAIN FALL CM	RUNOFF M3	TOTAL PHOS MG/L	ORTHO PHOS MG/L	FILTRD TOTL*PHOS MG/L	TKN MG/L	FILTRD TKN MG/L	NH3 MG/L	FILTRD NH3 MG/L	NO2+ NO3 MG/L	NO2 MG/L	INORG N MG/L	ORGAN N MG/L
05SEP79	7.16	241.0	0.12	0.00	.	1.41	0.50	0.18	0.05	0.00	.	0.05	1.23
06SEP79	8.10	808.3	0.05	0.00	0.00	0.78	0.45	0.00	0.00	0.00	.	0.00	0.78
07SEP79	0.00	1052.9	0.00	0.00	0.00	0.29	0.30	0.00	0.00	0.00	.	0.00	0.29
	TOTAL RAINFALL (CM):15.27						TOTAL RUNOFF (M3): 2102.2						
22SEP79	7.09	2121.7	0.00	0.00	0.00	0.43	0.62	0.35	0.00	0.06	.	0.06	0.08
24SEP79	0.84	1203.6	0.00	0.00	0.00	0.15	0.25	0.15	0.00	0.00	.	0.00	0.00
	TOTAL RAINFALL (CM): 7.92						TOTAL RUNOFF (M3): 3325.3						
14OCT79	1.02	247.0	0.09	0.00	0.00	0.10	0.12	0.00	0.03	0.00	.	0.03	0.10
	TOTAL RAINFALL (CM): 1.02						TOTAL RUNOFF (M3): 247.0						
04NOV79	4.78	682.5	0.06	0.00	0.00	0.42	0.15	0.00	0.00	0.00	.	0.00	0.42
	TOTAL RAINFALL (CM): 4.78						TOTAL RUNOFF (M3): 682.5						

TABLE D4 (Continued)

SINGLE LAND USE CATCHMENT

STORM EVENT COMPOSITE SAMPLING SUMMARY

STATION:NPS8 UNUSED MIXED FOREST

DATE(S)	RAIN FALL CM	RUNOFF M3	TOTAL PHOS MG/L	ORTHO PHOS MG/L	FILTRD TOTL*PHOS MG/L	TKN MG/L	FILTRD TKN MG/L	NH3 MG/L	FILTRD NH3 MG/L	NO2+ NO3 MG/L	NO2 MG/L	INORG N MG/L	ORGAN N MG/L
12NOV79	7.39	2063.4	0.07	0.00	0.00	0.65	0.30	0.10	0.00	0.00	.	0.00	0.55
14NOV79	1.30	1886.4	0.00	0.00	0.00	0.30	0.28	0.00	0.06	0.00	.	0.06	0.30
	TOTAL RAINFALL (CM): 8.69						TOTAL RUNOFF (M3): 3949.8						
07DEC79	0.36	130.0	0.09	0.00	0.06	.	.	.	0.06	0.00	.	0.06	.
	TOTAL RAINFALL (CM): 0.36						TOTAL RUNOFF (M3): 130.0						
14DEC79	1.22	246.1	0.00	0.00	0.00	0.10	.	0.00	.	0.02	.	.	0.10
	TOTAL RAINFALL (CM): 1.22						TOTAL RUNOFF (M3): 246.1						
19JAN80	2.64	638.3	0.00	0.00	0.00	0.24	0.18	0.00	0.00	0.00	.	0.00	0.24
	TOTAL RAINFALL (CM): 2.64						TOTAL RUNOFF (M3): 638.3						
23JAN80	2.16	390.5	0.06	0.00	0.00	0.18	0.00	0.00	0.01	0.04	.	0.05	0.18
	TOTAL RAINFALL (CM): 2.16						TOTAL RUNOFF (M3): 390.5						

TABLE D4 (Continued)

SINGLE LAND USE CATCHMENT

STORM EVENT COMPOSITE SAMPLING SUMMARY

STATION:NPS8 UNUSED MIXED FOREST

DATE(S)	RAIN FALL CM	RUNOFF M3	TOTAL PHOS MG/L	ORTHO PHOS MG/L	FILTRD TOTL*PHOS MG/L	TKN MG/L	FILTRD TKN MG/L	NH3 MG/L	FILTRD NH3 MG/L	NO2+ NO3 MG/L	NO2 MG/L	INORG N MG/L	ORGAN N MG/L
16FEB80	0.28	187.8	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.06	.	0.18	0.00
	TOTAL RAINFALL (CM): 0.28						TOTAL RUNOFF (M3): 187.8						
23FEB80	0.38	180.4	0.06	0.00	0.00	0.13	0.16	0.05	0.05	0.04	.	0.09	0.08
	TOTAL RAINFALL (CM): 0.38						TOTAL RUNOFF (M3): 180.4						
14MAR80	2.16	611.7	0.00	0.00	0.00	0.45	0.20	0.00	0.00	0.05	.	0.05	0.45
	TOTAL RAINFALL (CM): 2.16						TOTAL RUNOFF (M3): 611.7						
18MAR80	1.50	203.1	0.00	0.00	0.00	0.30	0.15	0.00	0.00	0.07	.	0.07	0.30
	TOTAL RAINFALL (CM): 1.50						TOTAL RUNOFF (M3): 203.1						
22MAR80	2.29	1516.8	0.08	0.00	0.00	0.49	0.24	0.00	0.00	0.00	.	0.00	0.49
	TOTAL RAINFALL (CM): 2.29						TOTAL RUNOFF (M3): 1516.8						

TABLE D4 (Continued)

SINGLE LAND USE CATCHMENT

STORM EVENT COMPOSITE SAMPLING SUMMARY

STATION:NPS8 UNUSED MIXED FOREST

DATE(S)	RAIN FALL CM	RUNOFF M3	TOTAL PHOS MG/L	ORTHO PHOS MG/L	FILTRD TOTL*PHOS MG/L	TKN MG/L	FILTRD TKN MG/L	NH3 MG/L	FILTRD NH3 MG/L	NO2+ NO3 MG/L	NO2 MG/L	INORG N MG/L	ORGAN N MG/L
25MAR80	0.56	284.0	0.00	0.00	0.00	0.00	0.12	0.00	.	0.00	.	0.00	0.00
	TOTAL RAINFALL (CM): 0.56						TOTAL RUNOFF (M3): 284.0						
29MAR80	2.27	287.7	0.00	0.00	0.00	0.22	0.10	0.00	0.00	0.00	.	0.00	0.22
	TOTAL RAINFALL (CM): 2.27						TOTAL RUNOFF (M3): 287.7						
10APR80	1.90	484.0	0.00	0.00	0.00	.	0.17	0.00	0.00	0.00	.	0.00	.
	TOTAL RAINFALL (CM): 1.90						TOTAL RUNOFF (M3): 484.0						
15APR80	2.03	471.8	0.00	0.00	0.00	0.32	0.12	0.00	0.00	0.00	.	0.00	0.32
	TOTAL RAINFALL (CM): 2.03						TOTAL RUNOFF (M3): 471.8						
28APR80	2.74	350.6	0.25	0.01	0.00	0.65	0.32	0.10	0.00	.	.	.	0.55
	TOTAL RAINFALL (CM): 2.74						TOTAL RUNOFF (M3): 350.6						

TABLE D4 (Continued)

SINGLE LAND USE CATCHMENT

STORM EVENT COMPOSITE SAMPLING SUMMARY

STATION:NPS8 UNUSED MIXED FOREST

DATE(S)	RAIN FALL CM	RUNOFF M3	TOTAL PHOS MG/L	ORTHO PHOS MG/L	FILTRD TOTL*PHOS MG/L	TKN MG/L	FILTRD TKN MG/L	NH3 MG/L	FILTRD NH3 MG/L	NO2+ NO3 MG/L	NO2 MG/L	INORG N MG/L	ORGAN N MG/L
30APR80	0.63	148.1	0.00	0.00	.	0.18	.	0.00	0.00	.	.	.	.
TOTAL RAINFALL (CM): 0.63						TOTAL RUNOFF (M3): 148.1							
01MAY80	4.44	1538.9	0.38	0.00	0.00	1.60	0.32	0.12	0.00	.	.	.	1.48
TOTAL RAINFALL (CM): 4.44						TOTAL RUNOFF (M3): 1538.9							
20MAY80	2.18	212.1	0.08	0.00	.	0.50	.	.	0.01	0.01	0.00	0.02	.
21MAY80	2.18	313.2	0.00	0.00	.	0.18	.	.	0.04	0.01	0.00	0.05	.
TOTAL RAINFALL (CM): 4.37						TOTAL RUNOFF (M3): 525.3							
23JUL80	9.93	384.3	0.16	0.00	.	0.90	0.40	0.00	0.02	0.03	.	0.05	.
TOTAL RAINFALL (CM): 9.93						TOTAL RUNOFF (M3): 384.3							
25SEP80	4.85	36.2	0.14	.	.	1.65	.	.	0.34	0.11	0.00	0.45	.
TOTAL RAINFALL (CM): 4.85						TOTAL RUNOFF (M3): 36.2							

TABLE D4 (Continued)

SINGLE LAND USE CATCHMENT

STORM EVENT COMPOSITE SAMPLING SUMMARY

STATION:NPS8 UNUSED MIXED FOREST

DATE(S)	RAIN FALL CM	RUNOFF M3	TOTAL PHOS MG/L	ORTHO PHOS MG/L	FILTRD TOTL*PHOS MG/L	TKN MG/L	FILTRD TKN MG/L	NH3 MG/L	FILTRD NH3 MG/L	NO2+ NO3 MG/L	NO2 MG/L	INORG N MG/L	ORGAN N MG/L
18NOV80	2.67	58.3	0.08	.	.	0.63	.	.	.	.	.	.	.
TOTAL RAINFALL (CM): 2.67						TOTAL RUNOFF (M3): 58.3							
29MAY81	4.80	113.6	0.09	0.00	.	0.66	0.30	.	0.00	0.00	0.00	0.00	.
TOTAL RAINFALL (CM): 4.80						TOTAL RUNOFF (M3): 113.6							